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CONSERVATION OF WATER BY THE RODENT DIPODOMYS

BY A. BRAZIER HOWELL AND I. GERSH

The ability of a number of desert mammals to dispense with free water has excited interest for many years, yet the subject has received but scant attention from physiologists. Babcock (1912) pointed out in comprehensive fashion the rôle which may be played by metabolic water, mostly in the case of insects. Some individuals have erroneously assumed that desert mammals, by some sort of alchemy, can manufacture more metabolic water than can their cousins of a more humid habitat.

It is common knowledge that many of the smaller desert mammals live miles from any water supply, where no rain may fall for more than a year. It is doubtful if some of them can obtain even drops of dew for months at a time. Even the larger inhabitants of such a region economize on water. However, the dearth of water in desert regions is probably a less serious problem than many suppose. Bailey (1923) has clearly shown that all over our arid regions there is available a wide range of succulent foods in the form of cactuses, juicy tubers, and roots, of which full advantage is taken by the local mammals. Hence it is very doubtful whether such mammals are ever reduced to a strictly air-dried diet. The mountain sheep nibble cactuses and must come to water every other day or so during the hot months, and the reputation of the camel is founded for the most part on the idle tales of travellers. The basis for the latter circumstance is the fact that the camel is less exacting in its water requirements than any other domesticated mammal, based supposedly upon the presence in its stomach wall of cells for storing water, and its fat-storing hump, which is the potential source of much metabolic water. During cool weather, when not working, and on succulent food, it can go for weeks without a drink, as can many ungulates of arid regions; but when working in high temperatures on dry food there is evidence (Marsh, 1856) to show that in Arabia a dromedary will exhibit signs of distress on the third or at least the fourth waterless day, although under such circumstances the animals

of northern Africa are reputed to be more tolerant, to the extent of one or two days.

Some of the Heteromyidae are probably able to withstand a greater degree of desiccation than any other North American mammal, but within the family there is much variation in this ability. Howell has kept many individuals of several species of *Dipodomys* on a diet of dry rolled oats, without water, for various periods of time up to three months, by which time they have usually lost a little weight and are fairly ravenous for moisture when they sense its proximity. Bailey (unpublished manuscript) attests to the fact, however, that members of this genus will lose condition if kept on such a diet and will die in a few weeks. Bailey (1923) has also reported that small, silky pocket mice (*Perognathus flavescens perniger* and *P. fasciatus*) will also lose condition after a few weeks of dry diet, and Benson (MS) states that *P. xanthonotus* will suffer if deprived of water for a week. On the other hand Stephens (1906) has reported *P. fallax* to have lived for three years exclusively on dry barley, and Benson that *P. penicillatus* will apparently do the same. Howell kept an individual of *P. fallax pallidus* for more than a year on a fare of dry rolled oats, at the end of which time it was in good condition, but was accidently killed.

It seems established then that at least some pocket mice can dispense entirely with both free water and succulent food. Not the least surprising fact in the above evidence, however, is the ability of such animals to survive for long periods in good condition on a diet of rolled oats, a food so incomplete as to prove fatal in a far shorter space of time to a white rat, even with access to water.

Additional interesting facts may be learned from animals in captivity. For two years C. P. Richter (MS) has studied certain aspects of two sorts of heteromyids in the laboratory. He has found that *Dipodomys ordii columbianus* consumes free water, in addition to a bit of lettuce once a week, to an amount varying from 2 to about 10 cc. per day. Strangely enough, the rate of consumption does not vary much in any particular individual; one will drink 2 to 2.5 cc. day after day for weeks, while another animal will consistently drink 8 cc. Young white rats of equal weight regularly drink more than the above maximum, or 10 to 12 cc. per day. The activity record of *Dipodomys* is quite variable, according to Richter, but individuals may run on an exercising wheel as far as 16 miles per night. The palm for restlessness must be accorded to *Perognathus fallax*, however. This species will not drink an appreciable amount of water at any time, Richter's records show, but it will run as far as 22 miles per night, an astonishing distance for such a rodent, particularly as such a small species must expend energy to turn the wheel; or, in other words, the animal is running uphill all the time.

After a *Dipodomys* has been on an air-dried diet for some time its behavior is noticeably different only in a few ways. It will reach back to receive the

fecal pellets as they are deposited and nibble these to pieces, so that it is impossible to determine the amount excreted. The bladder seems never to be completely emptied in micturition, and urine is voided only a drop or two at a time, but at fairly frequent intervals. It will not, apparently, consume its own urine as this leaves the urethra but will lick it from any surface that may be moist. And it will become considerably excited when it smells succulent food, such as apple. Whether activity actually decreases when the animal is on dry diet we are unable to say, but it appears to sleep more soundly.

When placed on an air-dried diet an adult white rat will survive an average of 5 days (Richter, MS), although an occasional individual may last a day or two longer. If moisture in some form be given before the ninety-sixth hour the animal will usually recover, but if withheld beyond this time it will usually die—a finding which is suggestive of the thesis that after the fourth day of a dry diet its system has frequently suffered some irreparable injury. At the fourth day it is obviously in some distress, with increasingly faltering gait and lethargy, so that it becomes less excited at the smell of moisture. It too nibbles its feces, and in addition will nibble its toes; *Dipodomys* has not been observed to do this.

METABOLIC WATER

Basal metabolism is the rate of oxidation of the tissues when an animal is at rest. It is increased by any sort of expenditure of energy. As in all oxidation the temperature (of the body) indicates the rate, but this is greatly augmented by activity. One of the products of oxidation is water, and this is referred to as metabolic water in animals. It is not formed from food directly, except from such slight putrefactive action as may take place in the intestines, but from oxidation in the body tissues. The quality of the food consumed can not affect it except indirectly in that carbohydrates or fats help build different substances in tissue. The digestive ability has nothing to do with it, and a desert mammal can secure no more metabolic water from its tissues than can an aquatic mammal, the body temperature of the two being equal.

The oxidation of proteins, fats, and carbohydrates, says Babcock (1912), produces a quantity of metabolic water nine times the weight of the hydrogen present. In table 1 is given the composition of 100 grams of air-dried rolled oats, as stated by Atwater (1906), and the maximum amount of metabolic water derivable therefore by any and all sorts of mammals.

Factors intimately connected with the rate of metabolism include rate of respiration, body temperature, and activity. It is obvious that the increase of any one of these, to secure more metabolic water, also increases the rate of water loss from the body, and a sort of vicious circle would then ensue. On the whole it would seem that an animal on a dry diet gets along better with a slow rate of living, and hence lower metabolism, than one that has to sacrifice much water by loss from the body concomitant to high metabolism. Hence, metabolic water is a critical factor to be accepted thankfully, like free water in the food, but its increase proves too expensive an undertaking to be practicable.

The elimination of the waste products derived from protein appears to cause the most difficulty for a mammal on a dry diet, for these are poisonous and can not be utilized. In the case of insects, reptiles, and birds this is done by the excretion of semisolid uric acid, but in mammals the end product is urea. When the end product is uric acid ap-

proximately 53 per cent of metabolic water is obtainable from nitrogenous oxidation, while with urea only 42 per cent is thus obtainable. The facts above set forth would suggest that a mammal on a diet low in protein would fare better than when on food high in this constituent. It would accordingly be expected that a desert mammal would be inclined toward a diet of an essentially non-nitrogenous character, for it would require less water to eliminate the end products.

Carbohydrates are able to furnish approximately 55 per cent (more or less in accordance with their hydrogen content) of their weight in metabolic water. Hence a desert mammal would be expected to prefer a diet high in carbohydrates.

The function of fats, or at least some of them, in the diet as they affect water requirements is a subject imperfectly understood. Thus it was found by Burr and Burr (1930) that white rats on a fat-free diet required almost twice as much water as animals furnished 10 drops of lard per day, although the excess water was not eliminated through the kidneys. Fats can furnish more than their own weight of metabolic water, and desert mammals might be expected to be partial to fatty foods.

Brief mention should here be made of Rubner's law, which is to the effect that basal metabolism does not vary with the body weight but with surface area. This is calculated by the formula of Meeh, utilizing a constant, k, which must be determined separately for different sorts of animals, a difficult or almost impossible undertaking in the case of a mammal as small as *Dipodomys*. The latter, with its chunky proportions, particularly when at rest, may be assumed to have a smaller surface area than a white rat of equal weight. This approach to the present problem, however, may be futile, for it was only meant to apply to laboratory animals with entirely comparable rates of metabolism. The latter is dependent upon thyroid action and many other factors, so that consideration of the surface area in an isolated case, such as in *Dipodomys*, might be very misleading.

WATER CONSERVATION BY MAMMALS

Water is given off from the body in three ways: (a) by water vapor from the lungs during respiration; (b) from the body surface; and (c) by excretion from the kidneys and in feces. If a mammal is to survive an air-dried diet for long periods it will have to conserve what it has in some or all of these ways. (a) An important method for reduction of water loss by respiration may be correlated with the effect of environment. The animal then presumably will be inactive during as large a proportion of the time as it can manage, so as to reduce the rate of respiration, and pick for its periods of activity the coolest, most humid part of the day. It will travel leisurely and no farther than necessary. It will have a burrow where the soil is as moist and cool as can be found, and will plug the burrow close to the nest chamber, so that the moisture of its breath will not be dissipated more than necessary. It will sleep curled up with its nose buried in its fur so that a part of the moisture expirated can be recovered at the next breath. At the same time there may be a lowered rate of metabolism, with a lower rate of breathing and reduced body temperature.

Most of the above details are regular habits of the Heteromyidae, although one cannot be sure that the rate and amount of activity while foraging are reduced when moisture is scarce. The rate of respiration in undisturbed *Dipodomys* on a moist diet was found to vary from 80 to 106 per minute, with an average of 93.7 (40 tests). After being on dry diet for 10 days the average was 53 (extremes 40 to 63); and after 17 days the average was 44 (extremes 25 to 72). The same individual was then put on moist diet once more and after 17 days of this the respiration rate, four hours after disturbance, averaged 130 per minute. This does not absolutely prove, but is good evidence for, a lowered rate of metabolism under arid conditions.

It was found, by keeping animals in small cages on precise scales and correcting for defecation and micturition when such occurred, that over an eight hour period two white rats on wet diet lost 2.5 and 2.6 per cent, respectively, of their initial weight. The percentage for 3 *Dipodomys* on wet diet was 2.68, 2.3, and 3.3; while for two animals on dry diet for 81 days the figures were 1.00 and 1.43 per cent. Not enough individuals were involved for these figures to be conclusive, but at least it suggests that heteromyids on dry food are successful in reducing the loss of water from the body surface and from the lungs. No attempt at separation of these items was made. The reader should also realize that the above figures include the carbon dioxide lost in respiration, which is doubtless greater than the water vapor given off.

The intraperitoneal temperature, taken immediately after the animal had lost consciousness under anaesthetic, proved to be too variable to be of much value in the present connection. White rats on wet diet varied from 89 to 95 degrees, and temperatures of *Dipodomys* on both wet and dry diets varied within the same limits to almost an equal extent. This merits further investigation with a more precise method.

(b) Loss of water from the body surface may be controlled by the environment in the same ways as for respiration and by curling the body while inactive so as to expose as little of the surface as possible; and by the reduction or elimination of sweat glands,

TABLE 1

	CHEMICAL ANALYSIS	MAXIMUM POTENTIAL WATER
	grams	*grams*
Free water	7.7	7.7
Proteins	16.7	6.9
Fats	7.3	7.8
Carbohydrates	66.2	36.7
Ash	2.1	
	100.0	59.1

development of an oily skin exudate, a suitable quality of pelage, and by reduction of metabolic rate, including temperature.

Rodents are supposed to lack sweat glands, although it is quite possible that there are a few, restricted to small areas. Even without them there occurs what is termed insensible perspiration, this being the loss of moisture by any surface not perfectly dry. The amount varies with the environment as well as bodily condition, such as temperature, and depends upon such factors as humidity of the air and air currents. The pelage of *Dipodomys*, and particularly of the more hispid pocket mice, does not impress one as being adapted to the retardation of evaporation from the skin; and yet the quality is rather peculiar in both, its unusual laxness in the former being essentially the same as in the Old World jerboas. Oily exudate of the skin is not strikingly characteristic, but when deprived of sand baths the animals take on an unkempt appearance, with matted hair, indicating that such an exudate is present.

(c) Water is lost in excretion by the alimentary canal and from the urinary bladder. Reduction of water lost with feces is a physiological adaptation so easily contrived that it merits no discussion.

One unit of the mammalian kidney is the glomerulus, involving an arterial capillary network which deposits in Bowman's capsule an exceedingly dilute fluid. This passes through the proximal convoluted tubule where some concentration takes place by re-

sorption, through the loop of Henle and distal convolution where great concentration takes place, and then through the collecting duct system, where again there may be some further concentration accomplished. Even in an individual (man) the quantity and quality of this fluid and of its subsequent concentration varies within wide limits, depending on particular foods ingested, water intake, blood pressure, and a number of other factors imperfectly understood. This resorptive capacity of various segments of the nephron is definitely augmented during dehydration of the animal, and Gersh has found that increased resorption in the dry-fed *Dipodomys* actually takes place in the ducts of the renal papilla.

There remained one other possibility in this connection. In birds and reptiles water is resorbed from the walls of the cloaca. When exposed to dry air frogs take up water from the structure that functions as a urinary bladder. During the dry season some species of Australian anurans, such as of the genus *Chiroleptes*, drink and absorb large quantities of water which is stored in the bladder and resorbed as needed (Sweet, 1907). Resorption of water from urine in frogs is not otherwise known, however, except under unusual experimental conditions, and the latter statement applies to the bladder of mammals as well. But Gersh has found that there is such resorption, to a very efficient degree, by the walls of the bladder of dehydrated *Dipodomys*.

RECORD OF EXPERIMENTS

Certain aspects of the experiments undertaken are of sufficient interest for discussion. They will be divided into two parts, the first involving the work done by Howell on *Dipodomys mohavensis* kindly furnished by W. H. Burt and Luther Little. E. K. Marshall generously made urine and blood analyses of these. The second part concerns the work done by Gersh.

Series A. The term dry-fed as here employed means that a *Dipodomys* has had access to no free water and only air-dried grains for a period of at least two weeks, and in the case of a white rat, for at least three days. A wet-fed animal has had all the moisture it needed, usually in the form of water but at times in the form of fresh apple or melon rind.

In weighing the animals over an 8 hour period to determine loss of weight, readings were made every half hour, and any excretion that occurred was promptly weighed separately and the results calculated so that they are the same as though no excretion occurred. In examining the results by means of graphs of these tests of the loss of weight occurring in wet-fed and dry-fed *Dipodomys* it was found that the greater part of the disparity between the two groups almost always occurred during the first hour and a half of the experiment; after that there was little difference in the weight lost. Similarly it was found that the rate of respiration in a wet-fed animal segregated in a small cage was at first always much higher, to the extent of approximately 30 per cent, than an hour and a half later, while in the dry-fed animal this initial increase was not marked. These facts indicate that although *Dipodomys* is particularly docile in captivity, yet wet-fed animals are more excitable, with consequent increase of metabolism, than dry-fed individuals, so that the latter, by their phlegmatic attitude, conserve their energies to a greater degree.

After an animal has been on dry diet for a couple of weeks there is marked irregularity in the respiration. Not only may the rate be double what it was the minute before, in spite of no increase in activity, but the slower rate is often characterized by several quick breaths followed by a long pause of two, three, or even four seconds. When the slower rate is followed the animal is usually if not always awake, while the animal appears usually to be asleep when the rate mounts above 60 per minute. It should be pointed out that a lessened rate of respiration in these animals is not absolute proof of a markedly lower oxygen consumption, for the breaths may be deeper, but it is pretty good evidence of this thesis.

The determination of the amount micturated by a kangaroo rat on dry diet is subject to considerable error. The method employed was to confine the animals, weighing from 54 to 60 grams, in wire cages 4 by 4 inches, with a sheet of cellophane beneath. Usually only a very small drop was voided every hour or two. Constant watch was kept and as soon as a micturition was observed the urine was drawn into a capillary pipette and then deposited in a glass tube in which had been placed 2 drops of toluene, for preservation. The tube was kept in ice water. The delay in recovery could not have averaged more than a couple of minutes but there was an element of error introduced by a small proportion of the urine adhering to the wires of the cage, and in two instances a part was projected beyond the edge of the cellophane. Experiments later made with drops of water indicated that loss in recovery might have run as high as 33 per cent. The amount actually secured in this way from three animals on a continuous test for 40 hours totalled 1 cc., or an average of 0.2 gram per animal per day. Allowing 33 per cent error the figure is 0.27 gram. For the determination of urine urea, percentage analysis was made by E. K. Marshall on smaller amounts of urine recovered at the instant of deposit. No 24-hour test of the amount of urine deposited by a *Dipodomys* on wet diet was undertaken, and an 8-hour test, with deposit of 2.08 cc., was too short to be trustworthy.

A young white rat (63 grams) on wet diet was tested for 24 hours, during which time it drank 15 cc. of water and micturated 7.2 cc. A test of this length is inconclusive for

TABLE 2

	BLOOD UREA	URINE UREA
	per cent	*per cent*
Dipodomys on dry diet 3 weeks	0.083	19.7; 17.2; 13.2
Dipodomys on grain and apple	0.03	1.43
White rat on dry diet 4 days	0.065	12.5; 9.2
White rat on grain and water	0.022	0.95

this animal, however, for we have had an individual go for 8 hours without voiding a drop, and then deposit 4 cc. of urine. It should also be mentioned that the feces of a white rat on wet diet may consist of one-third water.

A young white rat (50 grams) on the fourth day of a dry diet voided 0.51 cc. of urine in 24 hours. This need not indicate a greater loss of water (by drawing on the reserve of fatty tissue) than could be furnished by the ultimate metabolism of its daily food supply.

The percentage of blood urea and of urine urea of the animals on test was found by Dr. Marshall to be as shown in table 2.

It is seen from these figures that whereas urea occurs in the urine of some individual kangaroo rats on dry diet in greater concentration than appears to have been reported in any mammal, in other individuals it is not markedly higher than in the white rat on dry diet for a much shorter time. The significant point, however, is that in the dry-fed white rat the blood urea is actually lower than in the comparable *Dipodomys*, although the difference may well be within the limits of individual variation. In neither animal does the urea content of the blood mount to dangerous proportions. Hence one must believe that in the elimination of poisonous body wastes the kidney of the kangaroo rat is not definitely more efficient than that of the white rat.

Series B. The experiments undertaken by Gersh were designed to determine the chief sites of urine concentration (resorption) in dry-fed and wet-fed *Dipodomys agilis*

in contrast to the white rat, during which 10 animals (55 to 60 grams) were utilized. To be conclusive they must be repeated on a larger number of animals.

A wet-fed *Dipodomys* and a white rat (60 grams each) under ether were injected intravenously with 0.15 cc. of a 10 per cent solution of sodium ferrocyanide. After 10 minutes the kidney was removed and a slice frozen in liquid air. The tissue was dried in a low vacuum at −30°C. in order that, while frozen solid, the water should be removed, leaving the ferrocyanide *in situ* very nearly in the place occupied by it during life. The material was then embedded in paraffin and sections cut. These were tested on the slide for ferrocyanide, which was demonstrated as Prussian blue.

The resultant picture is very similar in both animals to that described by Gersh and Stieglitz (1934) for the rabbit; ferrocyanide can be observed in the glomerular space, in a slightly more concentrated form in the lumen of the proximal convolution, and still more concentrated in the loop of Henle, distal convolution, and duct system. In other words the ferrocyanide is eliminated in wet-fed *Dipodomys* and white rat, as in the rabbit, by the glomerulus and is concentrated in the same way, to some extent in the proximal convolution and duct system, but chiefly in the loop of Henle.

Having established the normal sites of resorption of water in the kidney two series of experiments were performed:

1. Four animals, a dry-fed and wet-fed *Dipodomys* and similarly treated white rats, were anesthetized with ether and 0.1 cc. of a 10 per cent solution of sodium ferrocyanide was injected into the femoral vein. After ten minutes the left renal artery and vein, and the ureter, were ligated close to the kidney, the latter was removed and a slice of it was frozen in liquid air.

Paraffin sections of this material showed the following: The wet-fed *Dipodomys* and white rat showed no ferrocyanide in the glomerular space and only a small amount in the lumen of the proximal convolution, while concentrated masses were present in the loop, distal convolution, and duct system. The dry-fed white rat showed no ferrocyanide in the glomerular capsule, a very slight increase in concentration in the proximal convolution, but a very pronounced concentration in the remaining portion of the nephron, which is typical of the rabbit and the dog under similar circumstances.

In contrast to the above, the dry-fed *Dipodomys* showed no ferrocyanide in the glomerular space, the same concentration in the lumen of the proximal convolution and the loop of Henle characteristic of the wet-fed control, and a very marked concentration of ferrocyanide in the large ducts of the papilla. Since ferrocyanide is dissolved in the urine but is not itself resorbed it follows that concentration of this substance in particular portions of the nephron indicates a similar concentration of the urine in those segments; hence resorption of water there. In other words the dry-fed white rat concentrates its urine in the kidney by utilizing its normal mechanism to an augmented extent, while the dry-fed *Dipodomys*, in addition to utilizing its normal mechanism, brings into play a greater resorptive activity by the larger ducts.

2. The second series of experiments was planned in order to see if the bladder, together with the duct epithelium, might play some part in urine concentration. The same technique was employed for the removal of the left kidney; then the right renal artery and vein and the ureter were ligated close to the kidney. The bladder was exposed and emptied by pressure. The external urethra was ligated and 0.25 cc. of a standard solution of phenolsulphonephthalein was injected into the bladder, after which the abdomen was closed. After 90 minutes the bladder was examined and it was found that there was no appreciable concentration of the bladder contents or reduction in its volume in the case either of the wet-fed *Dipodomys* and white rat or of the dry-fed white rat. But the bladder of the dry-fed *Dipodomys* was practically empty and free of phenolsulphonephthalein. In other words water and phenolsulphonephthalein are very quickly resorbed from the bladder of a dry-fed *Dipodomys* but not from that of the others.

It is suggested as a result of these experiments that water in the urine may be conserved for re-utilization by the dry-fed *Dipodomys* by means of the methods of resorption common to the kidney of other mammals, supplemented by a marked increase in the resorptive powers of the large ducts of the renal papilla, and by a resorption of water, and possibly of some crystaloids, in the bladder. This mechanism appears to be essentially similar in action to that of birds, which are also faced with the problem of water conservation. It may well be the critical factor in the physiological adaptation of desert rodents to an arid habitat. There are, however, many obscure angles to the problem, such as the part that hormones may play, which will involve a great deal of exceedingly specialized work if they are ever to be solved.

In summary it may be said that desert mammals probably obtain more succulent food than many realize. Some sorts can survive indefinitely with no moisture except that contained in air-dried food, and metabolic water, no more of which can be obtained by one sort of mammal than another. The rate of metabolism determines the total of the latter kind of water available over a period of time. Loss of water from the body takes place from the surface of the body, from the lungs, and by excretion. Condition of the body surface, habits and environment, as well as rate of metabolism, can control water loss from the first two sites. Habits and environment are favorable to such conservation in *Dipodomys*. In excretion water is conserved especially in the dry-fed *Dipodomys*, but not in wet-fed animals nor in white rats, by resorption of water in the ducts of the renal papillae and by the walls of the urinary bladder.

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BREEDING OF DASYURUS VIVERRINUS AND GENERAL OBSERVATIONS ON THE SPECIES

By D. H. Fleay

[*Plates 1–2*]

Early in 1932 a male specimen of the black type of the one-time widely spread native cat (*Dasyurus viverrinus*) was caged in an enclosure of moderate size with a normal yellow-gray female and her two surviving offspring (male and female) of the previous season. In the previous year (1931) the melanistic animal and the female (which carried the young ones in the pouch at that time) were captured at Dreeite near Lake Corangamite (V). In this district this species of dasyure appears to have escaped the effects of the devastating disease that almost exterminated the animals early in the century.

During April, May, and June (1932) a regular inspection of the fairly quiet female dasyure was made in the hope of following out carefully all the details in the event of the hoped-for production of young ones. In April and May the pouch area remained in its resting condition, being practically indistinguishable from the rest of the ventral surface, but towards the end of the first week in June it was noticed that reddish hairs were appearing in the pouch, while the anterior ridge of that area had become more prominent. In addition, the eight mammae were developing. By June 13 the shallow pouch was quite conspicuous with its growth of reddish hair, while the mammae were firm and pointed. Hope was entertained that the actual passage of embryos from cloaca to the mammae might be observed but unfortunately that event was missed, for, on the early morning of June 19, six minute offspring were already firmly established on the mammae. According to observations of the pairing, the black animal was almost certainly the male parent.

The eight mammae are arranged in two series of four, one series roughly parallel to the other in an antero-posterior direction on each side of the pouch. It was found that four embryos were gripping the nipples of the animal's right side while the remaining two were attached to the posterior mammae of the left side. The interior of the pouch at this time was extremely glandular and dotted profusely with white spots. The flesh-colored embryos in their curled-up posture measured 4 mm. in length and each individual was contained in a "pocket" or pit. The pouch itself remained continually moist and the mother sat up frequently to give it a thorough licking. She was removed without delay from the enclosure to prevent interference by the other inhabitants. At this time the limbs, tail, and ears of each embryo were the merest of rudiments, while minute blue pigment spots marked the position of the future eyes. The tiny creatures showed little movement, being apparently content to rest after the journey into the pouch. Growth, however, was fairly rapid and by June 21, on the third day, the embryos were almost twice

their size at the time of birth, while the stomachs were soon visible through the pink skins, with their bulging content of lacteal food. The mother submitted very quietly to being handled and her care and licking of the pouch and its occupants was very thorough and constant.

By June 26, at the end of the first week, the young dasyures measured approximately 11 mm. in length, being at least three times their size at birth. In addition, the embryos were no longer passive, for there was decided movement of the stunted limbs. By July 3 the moist, flesh-colored embryo dasyures were prominent in the pouch shelter, where formerly on the day of birth one had to look closely in order to distinguish the minute forms adhering to the points of the nipples. The heads were now more evident and the curled-up bodies measured 14 mm. in length. The arrangement of the litter was still very orderly, but when 20 mm. in length the youngsters sprawled in all directions, though tightly packed in the maternal shelter and attached as firmly as ever to the mammae. On July 18 they were 24 mm. long, and still lacking in pigment, though the crumpled ears were more noticeable.

By July 22, at the age of slightly more than one month, a number of interesting features were observed. On this date, when the mother was lifted from her nest, a faint crackling, sucking noise was audible from the embryos, which seemed to indicate that the little jaws were gaining the power of movement. In addition, the embryo on the upper teat of the animal's left side (above which were the two unoccupied mammae of the total number of eight) was observed to be developing at a slower rate than its five fellows. It was distinctly undersized and less active. This was interesting in view of the fact that this little animal proved later to be the only male in the litter. Actually, in the adult stage, the male is much bigger and more powerful. My experience with adult animals in the Western District seemed to indicate that males occurred in considerable excess over the females but the reverse was certainly true of these young ones.

The extraordinary tenacity with which the embryos hung to the extensile mammae was given a wonderful test at this time, when the mother chewed a small hole in the cage front just large enough to permit her head to push through. With immense difficulty she managed to squeeze the rest of her body with the entire crowd of young dasyures through this hole. Not one of them was dislodged. At this time they were quite conspicuous, with heads in and bodies hanging out of the pouch and by July 30 the faintest traces of pigment began to alter the hitherto pink bodies, appearing first of all anteriorly. This occurred at the age of six weeks and soon the pattern of white spots was thrown into general relief. At the same time hair began to grow on the bulky heads and on the shoulders, though the smaller male was still at least a week behind the vigorous little females in development. Gradually the fur and spots became more definite and all the young animals were of the same grayish color, which at the time seemed to indicate a disappointment in the ex-

pectation of obtaining some members of the melanistic type. The ears, though still small, were now taking shape and the claws of the digits were definite and sharp. The fore-feet possessed well-developed grasping powers. On August 19, at the age of two months, the young dasyures measured 75 mm. in length (less tail). The male was still the undersized member of the family. When the mother walked about at night the suspended bodies of the young ones were plainly visible; and during daylight, in the nest, the constantly moving tails and limbs attracted attention.

A significant stage was reached on August 23, when for the first time several of the short-furred blind youngsters were noted to have become detached from the mammae. When the mother was lifted from them they uttered sharp anxious cries of "cha"! "cha"! "cha"! and crawled vigorously about the nest, clutching with claws and teeth at each other or at anything of a furry nature that came within the field of their blind search.

This separation indeed indicated an interesting stage, for its significance lies in the fact that for at least nine weeks the female is heavily handicapped in her search for food with the burden of six or even eight large young ones dragging along from an attachment in the pouch area. This says a good deal for the hardy nature of both mother and young. From the manner in which this particular female struggled along in a painful hump-backed fashion it was very evident that she was far from being at ease. It is probable that in the wild state there may be some mortality within a week or two of this stage.

From now on the mother uttered an occasional defiant "er-chuck"! when handled during daylight, while the young animals in the grass nest (constructed by the mother) called lustily and struggled about to find her protecting body. Left to her own devices she would hurriedly rake any straying youngsters beneath her with vigorous scraping motions of her fore-paws and within a few seconds each offspring would attach itself tenaciously to a teat and from these positions it was almost impossible to dislodge them. If the mother was then lifted up, the six large offspring would simply hang to the elastic teats and drag over the ground when the mother attempted to run away.

All the young ones had shown the same grayish hue up to this time, but on August 12, at the age of nearly ten weeks, it was evident that three of the females were becoming darker. The nose, ears, and head region generally were very dark and it was observed that black fur was appearing on the head and gradually spreading backward. Within a week the contrast in color between the two types was most pronounced. At the same time, keeping pace with this, the remaining young dasyures showed the appearance of the more vivid yellow-gray fur, which also grew in the same sequence and replaced the first growth. The small parent was a devoted guardian of these offspring, and though she occasionally left the bunch asleep in the grass nest she rarely failed to return quickly at the anxious and insistent cries of "cha-cha" or

FIG. 1. Pouch of *Phascogale penicillata*, showing 3 embryos.

FIG. 2. Six teats in pouch of female *Dasyurus viverrinus* that had nursed young 18 weeks; 2 teats on left side hidden.

FIG. 3. Young dasyures 10 weeks old, with mother; two color phases first appear at this age.

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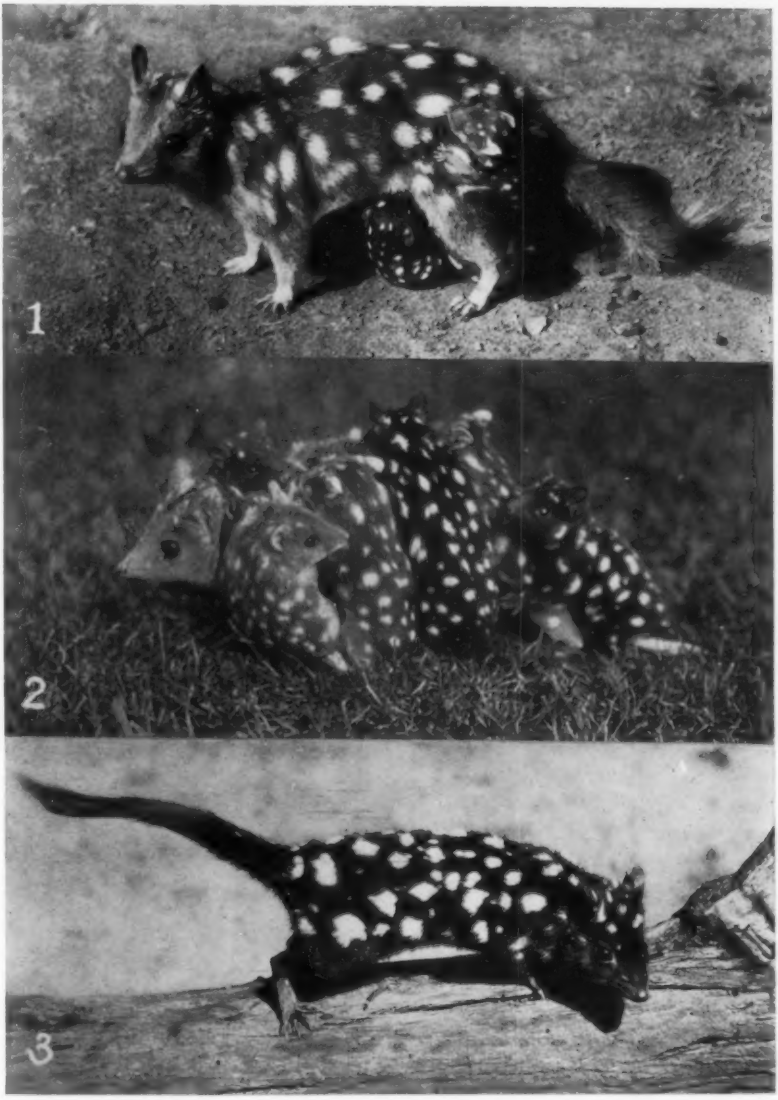

ADULT AND YOUNG DASYURUS VIVERRINUS

FIG. 1. Mother and 6 young; eyes of young open two days.
FIG. 2. Young dasyures 11 weeks old, clinging to mother.
FIG. 3. Melanistic female, 5 months old; brush on tail not fully developed.

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"shish", "shish" of a lost youngster, so like the voices of most marsupial infants. She could not move rapidly under the burden of all the young ones and she walked with a painfully arched back, and was easily caught when endeavoring to escape.

On September 7, at the age of 11 weeks, the young measured 100 mm. in head and body length and 150 mm. in all; the eyes were open for the first time and the single male was now almost equal in size to the others. The young now showed an amazingly fast transformation as they took an ever increasing interest in the world which had become visible to them. Occasionally, almost as a habit, they clung tenaciously to the mammae while the mother moved about, but now at 12 weeks of age when disturbed they clung with a bull-dog, "tooth and claw" grip to the fur of the mother's sides and back in the same manner as the young of *Sminthopsis crassicaudata*.

At 13 weeks of age they began to make furtive excursions away from the mother's side while she slept in the daytime, and though they did not bite, six little jaws gaped threateningly and a few ridiculous scolding cries were heard when my hand approached the nest. The young animals would anxiously chase the nearest moving object if they were placed on the ground and it was interesting to watch the whole batch rushing at a young wombat, leaping on to its back and immediately clinging like glue in the belief that their mother had been found. They still clung at times to the elastic mammae though they had now attained a length of 150 mm. in head and body, and 90 mm. in tail. These mammae, which had grown gradually larger from the time of birth, were 15 mm. long in repose, but they readily stretched out to a length of 35–40 mm. when pulled by the young dasyures.

In mid-October, at the age of some 16 weeks, the young though still suckling, were extremely venturesome and interesting. They were accustomed to being handled and were now simply small editions of the adult animal, though lacking the slight brush on the tail. The young male was now obviously the most robust member of the litter, and the little animals were not slow to eat the mother's food. One evening when brought into a room they lost no time in scenting out and devouring two newly emerged emperor moths (*Antheraea*) hanging to the curtains. Towards the end of October all the young animals became quite independent and ceased to cling to the mother. They were entirely capable of an independent existence after approximately 4½ months passed in her very devoted care.

Now the mammae entered the stage of retrogression, though three of them suppurated owing to the sharp little teeth of the active young ones. These young dasyures made a very bright and interesting spectacle as they indulged in all the vivacious antics of the play-age. Frequently after nightfall they were brought into a drawing-room and from the moment of liberation they careered over the floor, about the couches and up the curtains, and wrestled with one another for hours. The three members of the black type and the

three normal animals offered a most striking and interesting contrast as they frolicked in the evening.

Marsupials may be primitive, unintelligent mammals by comparison, but this particular species seems to compare very favorably with members of the Eutherian order, for tame dasyures retain their playful habits in the adult period. The young ones displayed a habit of sneaking furtively up to smell some object and then bolting erratically away with tails held in a vertical position. They also sat bolt upright with ears forward and fore-paws folded down on the chest in the typical attentive attitude of the adult dasyure. They had a practice of wrestling in this upright position, chest to chest, reminiscent of the attitude of kangaroos. These friendly bouts were accompanied by attempts to bite each other's throats playfully, but good temper was unfailing.

They delighted in chasing tennis balls about the floor, and in leaping high into the air in pursuit of blowflies during the daytime. Like all members of the species they loved sunlight and basked in it for hours at a time, despite their nocturnal habits. By the end of November all had reached adult size and it was difficult to distinguish the mother from her daughters, while the robust build and richer yellow color of the young male at once distinguished him. Until this time the tails of the young dasyures had been close-furred but now they gradually developed the slight brush characteristic of the adult.

On May 17, 1933, it was observed that the pouch areas of the young dasyures were developing thick reddish fur; soon the teats became red and pointed and the whole area was characteristically moist. By the end of the month the pouch of the mother also showed signs of re-development, though the profuse reddish fur of the younger females did not appear. Then very rapidly, on June 16 and 17, it became moist and glandular and each pointed teat became the center of a small ridged circle.

Being very anxious to observe the actual passage of the embryos from cloaca to the pouch I handled both this quiet animal and her daughters (all of which should have been pregnant) rather too frequently. Probably the embryos were destroyed following birth, for by July 1 none had been observed and all the pouches had reverted to the shrunken state. Also, instead of hiding away and resting as the animals usually do before the birth of embryos, the dasyures had again become very active and playful. No young have appeared up to November 13, 1933.

An interesting comparison with the growth of this brood is afforded by the fact that in August, 1931, this mother dasyure was captured near Dreeite with the maximum number of eight "joeys" in the pouch; the proportion of sexes here was five females to three males. Six of the young animals fell out of the pouch during the journey to Melbourne and died from the effects of exposure. Only two survived, one male and one female. When they were apparently some nine weeks of age (calculated from the development of the 1932 litter)

the two young animals were similar in size to each other, but here also the male rapidly became more robust from this stage onward, exactly as in the case of the litter produced in captivity. Though only these two cases are known to me, the excess of young females is in strong contrast to the results of hunting and trapping with drop-door traps in the Corangamite district. Here my experiences, borne out by those of local people, have shown an average of at least 10 of the larger and stronger males to a single female.

GENERAL OBSERVATIONS

In May, 1931, I spent a week wandering about the basalt country of the Western District by Lake Corangamite, searching both by day and night for traces of the dasyures.

Under heaped-up boulders were found "dining-lairs", which contained a wide assortment of sheep and rabbit bones. The presence of sheep skulls under these rocks was almost unexplainable and in most cases these "relics" must have been dragged from a slaughter yard quite half a mile distant—all for the sake of a leisurely meal in seclusion. In captivity the same habit is observed, for the animals immediately carry delicacies, such as fish, to a sheltered spot.

A well developed nest-building instinct is present in *Dasyurus viverrinus*, though the females are the only ones that I have observed gathering the material—dry grass, bark, or scraps of hessian. A fairly comfortable bed is established in a hollow log or under a boulder. One female with young captured in the Western District was discovered in a grass nest under a heap of basalt rocks. When asleep the animals often roll up into a vertical ball with the head tucked into the abdomen in the manner of opossums (*Trichosurus*).

Another curious fact common to some other marsupials is that the dasyures are occasionally found partly dormant or sluggish on a cold morning, though nightfall again finds them very active.

The ordinary yellow-brown type predominates in the Corangamite area, as elsewhere, and the uncommon black animals are present in the probable ratio of 1 to 20 or 30. In addition there is the dark brown type, rarely encountered. I have one such skin which was nailed to a wall at Dreeite (V.).

The adult animals from this district supported a host of parasites and when first brought to Melbourne, before being treated, they carried numerous large ticks and open sores infested with fly larvae. In addition the peculiar flea, *Stephanocircus dasyuri*, was found on them and investigations on dead dasyures that had been caught in rabbit traps revealed numerous nematode worms internally.

The vocal sounds of the young dasyures and some of those uttered by the mother have been described previously and as in the case of many other marsupials the notes are variations of a hissing cry. When the animals are at bay a low, prolonged ominous note is heard followed by a few sharp hissing

noises while the jaws gape open, displaying the keen white teeth. The noise made by *Dasyurus maculatus*—the larger spotted-tailed species—and also that made by *Phascogale penicillata*, are similar to this under like circumstances. In the frequent nocturnal squabbles, which are seldom accompanied by any actual damage, the characteristic far-sounding "er-shish'-a", begun in a guttural tone and with pronounced and penetrating emphasis on the second syllable, may be repeated many times.

In addition short, sharp, guttural coughing noises are suggestive of a man clearing his throat. Again the "er-shish-a" cry, in a moment of intense quarreling, is begun with the guttural first syllable, and then the second penetrating hissing note is uttered six or seven times very rapidly (e.g., "er-shish-shish-shish" etc.). These quarreling cries were very familiar sounds to bushmen of earlier days for in hundreds of cases the dasyures lived beneath the floors of huts and their bumping heads and squabbling cries were familiar sounds at night.

Melbourne, Australia.

NOTES ON FOOD OF RED FOXES IN NEW YORK AND NEW ENGLAND

By W. J. Hamilton, Jr.

In 1927 the writer commenced a study of the food of certain predatory fur-bearers in New York. Of over two thousand carcasses or stomachs examined, the red fox numbers more than two hundred. Effort was made to get fox stomachs, or the entire carcass, from trappers, hunters, and fur buyers, with moderate success. For supplying me with considerable numbers, I am indebted to Gardiner Bump, of the New York State Conservation Department; Elton Clark, of Framingham, Massachusetts; Ainslie Lawrence, of St. Albans, Vermont; Dorman Purdy, of Ithaca, New York; Clarence Bowdish, of Esperance, New York; and William C. Matson, of Williamstown, Vermont. Others too numerous to mention have supplied me with two or three fox stomachs.

In all, 229 stomachs were examined, 23 of which proved to be empty, leaving a total of 206 stomachs that had food in sufficient quantities to make an analysis desirable. These were collected over a period of eight years, from 1927 to 1934. The animals were killed from October to March, but most of them were taken in the late fall and early winter (13 in October, 89 in November, 43 in December, 49 in January, 29 in February, and 6 in March).

Table 1 indicates the frequency of occurrence of the various food items, and the percentage of bulk each occupies in the total food volume. A discussion of these various foods is in order.

Mice.—Various species of mice were found in 40 per cent of the stomachs examined; they comprised 29.3 per cent by bulk of all foods eaten. This is to be expected, as all who have studied and written on the food of foxes will agree. The abundance of the microtine population and their ease of capture make of them a most important item in the dietary of the fox. The species favored, or most readily accessible, is the ubiquitous meadow mouse, *Microtus pennsylvanicus*. To find three or four in a single fox stomach is not unusual. Elton Clark found eight and the remains of additional individuals in one stomach. Of the 83 foxes that had swallowed mice, ten were found with the remains of deer mice (*Peromyscus*), while four had eaten red-backed mice (*Clethrionomys*).

Rabbits.—Cottontails are next favored, during the fall and winter. Occurring in 27.2 per cent of the stomachs examined, they make up 22.1 per cent of the bulk. Apparently no part is left uneaten, for the ears, teeth, feet, and claws and large masses of

TABLE 1

Stomach Analysis of 206 Fall and Winter Red Foxes from New York and New England

KIND OF FOOD	NUMBER TIMES PRESENT	PERCENTAGE BY BULK
Mice	83	29.3
Rabbits	56	22.1
Grasses	51	13.9
Sticks, dirt, trash	33	6.2
Carrion	17	8.1
Fruit	18	5.3
Insects	11	3.4
Poultry	11	3.1
Squirrels	9	2.9
Porcupine	4	1.8
Game birds	5	1.4
Small birds	3	0.5
Shrews	3	0.8
Worms	3	0.8
Grain and nuts	3	0.4

fur are frequently encountered in the stomachs or visceral tracts. Of the 56 that contained rabbit, seven had eaten *Lepus*, the remainder *Sylvilagus*.

Grasses.—It is not at all unusual to find various grasses in the stomachs of foxes that have been shot. They constitute 13.9 per cent of the food eaten and occur in 25.1 per cent of the stomachs examined. Often an amount equal to a good handful will be taken from an animal. Apparently winter wheat is often consumed, while other grasses, undetermined, are frequently met with in the analysis of stomachs collected during the winter months.

Sticks, dirt, and trash.—A trapped animal will occasionally swallow bits of wood, sticks, dirt, and dead leaves in its frantic efforts to free itself. Likewise, in catching mice some grass is inadvertently swallowed. Such material goes to make up 6.2 per cent of the bulk of stomach contents and was found in 16.1 per cent of the animals studied.

Carrion.—Foxes will frequent the vicinity of a slaughtering house and make off with any offal they can secure. Dead cattle, horses, and sheep are fed upon as occasion permits, particularly during the cold months when other food is scarce or not easily

procured. Deer, killed by hunters during the fall, are a favorite food of foxes during the winter season in the Adirondack region of New York. Many cases have come to the attention of the writer where this has been a most important item of sustenance during winter. Of the animals examined, carrion occurred in the stomachs of 8.3 per cent, and made up 8.1 per cent of the bulk of food.

Fruit.—Among the various fruits and berries, the apple takes first place. It is usually to be found in some part of the foxes' range, and during heavy snows and in periods of general food scarcity, this frozen fruit is a staple. Aside from stomach analysis, droppings collected during periods of heavy snow show the characteristic apple remains, with parts of the skin and seed. Another important article of sustenance during late fall are the wild cherries that are found in abundance over much of this animal's range. One stomach contained the fruit and stones of 230 rum cherries (*Prunus serotina*). The fruit of partridge berry (*Mitchella*), wintergreen (*Pyrola*), Virginia creeper (*Psedera*), and various wild grapes (*Vitis*) are frequently eaten. Fruit remains were found in 8.7 per cent of the foxes examined, and comprised 5.3 per cent of the bulk.

Insects.—While insects occur in 5.3 per cent of the stomachs examined, they constitute only 3.4 per cent of the bulk. Even at this, it appears an appreciable amount is eaten, especially during the fall months. Grasshoppers, crickets, beetles, millipedes, and sowbugs are consumed. While the latter two are of course not insects, they are grouped with this order for convenience.

Poultry.—Hen feathers appear in 5.3 per cent of the animals examined, and constitute 3.1 per cent of the bulk of the food consumed. While fowls are taken in considerable numbers during the spring and summer months, it seems more likely that this item, at least during the winter months, is in the form of dead poultry that has been thrown out by the farmer. My records certainly indicate this, as they do for the skunk.

Squirrels.—Nine stomachs contained sciurid remains, which constitute 2.9 per cent of the bulk of the food eaten. Gray squirrels were found in four stomachs, chipmunks in a like number, while one fox had eaten a flying squirrel. I once saw the remains of a gray squirrel on the snow that had been caught and eaten, excepting the tail, by a fox. I suspected that it was the work of a gray fox. T. Donald Carter, of the American Museum of Natural History, writes me of a den of the gray fox he found in northern New Jersey. He says, in part: "One den showed many rabbit remains and also a surprising number of gray squirrels, but squirrels were very numerous that year."

Porcupine.—We have been led to believe, from the writings of many naturalists, that the fisher is the only mammal that safely circumvents the strong armor of the porcupine and makes a cautious meal of it. The fox certainly feeds upon the porcupine occasionally, for analysis of stomach contents shows quills, fur, and flesh of this animal in four stomachs examined, and Elton Clark found porcupine remains in a fox he examined. Where "porkies" are common, the fox frequently brings them to its young.

Game Birds.—Five of the 206 stomachs that contained food held game birds. Three of these contained grouse, and two, pheasants. Of 67 red fox stomachs examined by Elton Clark, one contained a grouse.

Small Birds.—As a rule, passerine birds are too quick for foxes to capture during the fall and winter. A junco, a tree sparrow, and a blue jay were the species taken. How blue jays are caught must be left to conjecture, but captured they are, and not infrequently. Elton Clark took a jay from the stomach of a fox he shot on October 29, 1929, at Plainfield, New Hampshire. Among the small bird remains about the dens during late spring, the blue jay is the species most frequently encountered.

Shrews.—Three stomachs contained shrews. One fox examined, from Pawling, New York, had bolted three *Blarina* entire.

Worms.—Earthworms were found in the stomachs of 1.5 per cent of the animals taken during the fall. Like the raccoon, skunk, and opossum, foxes are not averse to adding

Lumbricus to their menu, and after heavy late fall rains, the worms are frequently sought.

Grain and nuts.—I have found beechnuts, corn, buckwheat, and acorns in the stomachs of red foxes collected during October and November. Elton Clark records corn from four stomachs and nuts from three.

Finally, one stomach contained a Norway rat.

The winter food habits of foxes in central New York, as reflected in their droppings, comprise the following items, found in 54 pellets:

Apple remains	Found in 29
Rabbit fur and bones	Found in 13
Mouse fur and bones	Found in 18
Berries (stones of *Viburnum plantago*)	Found in 3
Grasses	Found in 10
Poultry feathers	Found in 6

TABLE 2

Stomach Contents of 66 Red Foxes Taken in Vermont, New Hampshire, and Massachusetts during the Fall and Winter, 1913 to 1932

FOOD ITEM	NUMBER OF TIMES PRESENT
Mice	33
Fruit (principally apple and wild cherries)	32
Grasses	14
Rabbits	8
Poultry	6
Carrion	5
Corn	4
Insects (grasshoppers, crickets)	3
Squirrel (gray)	3
Woodchuck	3
Muskrat	2
Nuts (beechnuts, chestnuts)	2
Skunk	2
Porcupine	1
Grouse	1
Blue jay	1
Rat	1

Elton Clark, of Framingham, Massachusetts, has been hunting foxes and studying their habits for the past quarter century. Mr. Clark has sent the writer a considerable number of stomachs, and volunteered a lengthy report on his own stomach analysis of the foxes secured by him in New England. The report, listing observations on the stomach contents of 66 foxes examined between 1913 and 1932, gives a fair cross section of the fall and winter food of the red fox in southern Vermont, New Hampshire, and Massachusetts. A condensation of Mr. Clark's report is given in table 2.

SPRING AND SUMMER FOOD

To secure unpublished data on the food of the red fox during the spring and summer, as noted about the dens, letters requesting such information were sent to a number of

New York and New England members of the American Society of Mammalogists. Table 3 lists the various food items at the dens, the number of dens where such were encountered, and the total number of specimens found.

My own observations about seven red fox dens in central New York and eastern Massachusetts during May to July include such items as woodchucks, poultry, rabbits, two pheasants, muskrats, chipmunks, blue jays, crow feathers, and an occasional short-tailed shrew (*Blarina*).

During July and August, 1934, Mr. E. E. Brown collected fifty fox droppings in Fulton and Hamilton counties, in the foothills of the Adirondacks. The writer collected sixty droppings during the summer of 1934 in Herkimer, Oneida, and Cortland counties. All droppings were fairly fresh and indicated a fair cross section of the food of the red fox at that season.

TABLE 3

Food Remains in about 31 Red Fox Dens, New York and New England

FOOD	NUMBER OF DENS	NUMBER OF SPECIMENS
Woodchuck	15	33+
Rabbits	10	22+
Poultry	9	13
Game birds	5	6
Moles and shrews	5	5
Muskrat	4	5+
Crow	3	3+
Small birds	5	8
Squirrels	3	4
Cat	2	2
Insects	2	many
Rat	1	1
Porcupine	1	1
Carrion	1	1
Weasel	1	1
Reptiles	2	5

Recognizable remains were found in 106 droppings. The fruit of bristly sarsaparilla (*Aralia hispida*) was found in 68 fecal remains. Mice and shrews were recognized in 43 droppings. The seeds and pulp of blueberries were evident in 37 droppings, while 35 contained insect remains. Rabbit fur occurred in 16 scats. The fruit of the service berry (*Amelanchier*) was recorded 11 times; this appears to be a food of first importance to this animal. Red squirrel and chipmunk fur was found in 11 droppings, while snakes were represented twice.

During the nesting season of our game birds, and while the young birds are still being protected by the adult, the abundance of wild fruits and berries tends to reduce the destruction of birds by the fox. Wild fruits and small rodents, where abundant enough, act as a buffer agency in supplying the fox with its immediate needs during the critical breeding season of the grouse. It has been established that fruits and berries are brought to the cubs before they leave the den.

The following notes are extracts of personal letters. The observer and place of observation are listed with notes on red fox food items.

Lester W. Smith, Babson Park, Boston, Massachusetts. Two muskrats, one shrew, two woodchucks, gray squirrel, two pheasants, one grouse, and four domestic hens.

John D. Smith, Boston Society Natural History, Boston, Massachusetts. Woodchucks, black ducks, rabbits, an occasional hen pheasant, no grouse, many house cats, rarely a gray squirrel, and towhees.

Earle A. Brooks, Moultonboro, New Hampshire. Rabbits, poultry, and many porcupine quills.

Dunbar Lockwood, Cambridge, Massachusetts. "I am impressed by the number of woodchuck remains around fox dens. I have seen almost no partridge or pheasant feathers and very little mouse evidence, one black duck, and a number of muskrats, with, of course, rabbits and an occasional chicken."

Wendell P. Smith, Wells River, Vermont. Numerous woodchucks, some poultry, snowshoe hare, domestic cat, crow, offal from slaughter house, and a grouse.

Lawrence Harper, Parishville, New York. Four or five muskrats.

Roy Latham, Orient, Long Island, has actually seen foxes catch muskrats, moles, leopard- and bull-frogs, and he records about the dens the following items: Wild ducks (scoters), domestic ducks and infertile eggs, and cottontails. He gives evidence that foxes feed upon pine, meadow, and deer mice; dig out the eggs of snapping, painted, and box turtles; and the unmarketable marine fish, dumped by the trap fishermen, are fed upon by foxes from April to November. Foxes have been instrumental in breaking up a large colony of breeding terns.

Arthur H. Helme, Port Jefferson, Long Island. Anything in the way of flesh the old foxes could obtain. Ducks, skates, cottontails (many), weasels, moles, and carrion. A two-thirds grown fox killed at night by an auto had its stomach filled with blueberries.

John T. Nichols, Mastic, Long Island. Majority of snapping turtle nests destroyed by foxes, which dig up and eat the eggs.

Reference to literature throws little light on the summer dietary habits of the red fox in New York and New England. The most extended account is given by Crosman (1927) who lists the vulpine menu as determined by weekly visits to fox dens over a period of years. The locality was in the vicinity of Canton, Massachusetts. Great blue heron, young pig, poultry (hens, ducks, and geese), small birds, with blue jay most numerous, towhee, muskrats, red and gray squirrel, cottontails, spotted and painted turtle, and a great many of the larger beetles are all listed by this author.

Dr. Charles W. Townsend (1913, p. 53), from examinations of fox droppings on the sand dunes of Ipswich, Massachusetts, lists sand fleas and sea scuds, June beetles, tiger beetles, bones of toads and frogs, feathers of birds (among them being poultry, night herons and others), mice, rabbits, and the teeth of a young skunk.

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SWIMMING OF THE MUSKRAT

By John D. Mizelle

Heretofore much controversy has arisen in regard to the aquatic locomotion of the muskrat. Evidently this is due to a lack of observation of the process in water clear enough so that the animal could be seen in every phase of swimming.

A. B. Howell (1930, p. 36) says: "Swimming is accomplished by means of alternate thrusts of the hind feet and accompanying horizontal movements of the tail; and I have been led to believe that occasionally the tail is thus used alone, while the feet are trailed."

Kirkwood (1931, p. 318) states: "The fore paws were held close together, palms outward and pressed close up under the chin . . . the powerful hind feet and legs worked alternately. This gave the rump a cross see-saw motion which extended to the tip of the tail in a wavy motion in which I could detect no propulsory power. . . . In entering the water, if not scared they went in just as a dog might but if startled they dived in head first and no doubt used both hind feet simultaneously for the spring. The only use I ever saw the fore feet put to was in washing a piece of root brought to the bank in the mouth."

Dugmore (1914, p. 213), in comparing the muskrat with the beaver, says: "In this respect it [the beaver] differs entirely from the muskrat, which swims entirely with its tail, which acts as a scull."

Johnson (1925, p. 284) states: "They swam with their feet, and not with their tails. While I could not in either case see the foot of the opposite side and thus be able to tell positively whether the two feet worked both at once or alternately, I judged from the action of the body that the strokes were made simultaneously, exactly as in the case of the beaver. There were tail movements, to be sure, but these were of a feeble and irregular kind that could only be interpreted as steering movements. A number of muskrats which I have since watched while they were swimming leisurely and unalarmed . . . swam steadily and without any vigorous or continuous movements of the tail which might indicate that this organ was being used as a scull in the proper sense of the word."

Svihla (1931, p. 16) states that, in swimming, both the front and hind feet are used alternately and not simultaneously as has been suggested by Dr. Johnson in his "Muskrat in New York."

Stanley C. Arthur (1931, p. 282) tells us that, "When the muskrat is leisurely swimming, either in still water or with the current, when it is not necessary for it to exert any extraordinary swimming power, it uses all four feet in progressing through the water. During this leisurely method of swimming it was noted that both the front and hind feet were used, sometimes alternately, and at other times simultaneously. When swimming with the current

or in slack water, the tail apparently is not used for any purpose whatsoever, either for sculling or for use as a rudder, as has been frequently stated, but this appendage merely trails behind the body that is being propelled through the water by the animal's feet. . . . But when it was necessary for the animal to buck a current, not only were the fore feet used with great energy, but the tail was called upon to aid in its progression, and this flattened sinewy member was given a writhing, sculling motion, somewhat akin to the swimming motions of a snake, that evidently was of as much use to it as an auxilliary motor and propeller are to a sailing vessel."

Recent experiments at the Louisiana State University on this phase of the animal's activities have tended to clear up the matter. The site of experimentation was a concrete pool (5 ft. 10 in. × 20 ft. 6 in.) on the south side of the Biology building. This place was drained, cleaned and filled to a depth of one and one-half feet with clear water. The animal was clearly visible in every phase of swimming both on and below the surface of the water.

On entering the water the muskrat goes in like a dog, with little or no splash, but if alarmed it enters with a rush, making a sharp cracking noise against the surface of the water with its flattened tail.

The muskrat's aquatic locomotion is divided into two phases, surface and submerged swimming. In neither phase are the fore feet used; they are held motionless under the chin, palms inward. The head is elevated somewhat and this together with the position of the fore legs gives the animal a fusiform or spindle shape characteristic of the sea-going and burrowing forms.

In surface swimming the animal was observed to propel itself forward with alternate strokes of the hind feet, the structure of which in regard to aquatic adaptation consists of a slight webbing between the toes. In addition there are rows of stiff, posteriorly directed hairs measuring from two to three millimeters in length on each side of the toes and sufficient in number to form a fringe reminiscent of analogous structures on the feet of the colymbiform birds and on the legs of water beetles (*Hydrophilus triangularis*). The hairs on the outer side of the little toe extend from the tip of the toe, just behind the claw, onto the foot and merge with the hair on the leg. On the outer or lateral side of the hallux, the fringe extends about half way to the ankle joint. The hairs on the rest of the digits extend from just behind the claw on both sides to the articulation of the digit and merge with the hairs of the feet. The strokes of the hind feet were in almost a vertical plane, deviating approximately five to fifteen degrees to the outside of the plane. On the forward stroke the foot is folded up like that of a duck, thereby cutting down the braking power of the appendage on the return forward. On the backward stroke the digits are extended laterally so as to utilize the interdigital webbing to a maximum degree. The propelling movement of the hind limb comes principally from the ankle joint, but to a slight degree from the knee. Movement of the femur is imperceptible. The posture assumed by the limb in the proc-

ess made it impossible to estimate the relative positions of the component parts. The undulation of the body in the animals under observation was practically nil. The tail was not used, but was trailed in a straight line without the characteristic undulatory motion so often referred to. The speed of the animal in surface swimming was estimated to be from one to three miles per hour. In turning, the animal altered the strokes of the hind feet of one side or the other to gain the new direction. The only observed use of the fore feet, in the animal's aquatic activities was that of assisting in the surface dives, at which time one or two simultaneous strikes were made to facilitate submergence.

In submerged swimming the process is different. The position of the fore feet and assumption of body form is the same as described above. The strokes of the hind feet are as in surface swimming except that the stroke is made in a nearly horizontal plane instead of in a vertical one. The stroke deviates below the horizontal about five to fifteen degrees and is made to a greater extent with the feet than in the former process. There is less movement of the shank than in surface swimming. The motion of the thigh, if any, was imperceptible. The thigh is directed anteriorly at an angle of about thirty-five degrees to the longitudinal body axis. The hind feet describe an arc of approximately ninety degrees in the stroke. In sharp contrast to the first phase of swimming the tail is brought into play and at all times when under the water the animal uses it vigorously, making lateral strokes toward the feet in the backward motion. On stimulation, the strokes became faster than the combined rates of both hind feet but in ordinary swimming were equal to the two, the direction being toward that of the feet and tending to make the animal's course a straight line. Obviously, turning is attained in the same manner as in surface swimming. The use of the tail is that of a scull. Whether or not the muskrat uses its tail as a rudder in swift water was not determined. However, it seems quite possible that it could do so, if necessary, for on dissection four bundles of tendons, two dorso-lateral and two ventro-lateral, are found to take origin from the rump muscles and run the full length of the tail, cropping out along the way to make attachment to the skeletal structures of the caudal appendage. The tail is held rigid from the rump to a point approximately on line with the end of the extended foot, indicating this space between the two points to be the part of greatest use in the process. The rest of the tail waved in an undulatory fashion.

When undisturbed on land the muskrat moves with an ambling gait at a relatively low rate of speed. The movements of the fore and hind legs are alternate. The tail drags on the surface with a sidewise movement. When scared the animal moves by leaps made by simultaneous movements of the fore and hind limbs.

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INHERITANCE OF WALTZING AND OF EPILEPSY IN MICE OF THE GENUS PEROMYSCUS

BY LEE R. DICE

In the colony of deer-mice of the genus *Peromyscus* that has been maintained for a number of years at the University of Michigan the waltzing character has appeared independently in four different stocks, while epilepsy has been found also in four separate stocks, in two of which it is associated with waltzing.

The stocks of mice used in this study have been collected by Paul A. Moody, G. W. Bradt and assistants, Arthur and Ruth Svihla, and myself. The William P. Harris, Jr., Research Fund of the University of Michigan Museum of Zoology and the Carnegie Institution of Washington each helped to finance expeditions on which certain of the stocks were secured. A research grant from the American Association for the Advancement of Science has made possible the rearing of sufficient animals to bring the study to the present stage of completion. H. W. Feldman has kindly read the manuscript.

Three of the four stocks in which waltzing has appeared belong to three subspecies of *Peromyscus maniculatus*, namely, *P.m. artemisiae* from Lyon's Ferry, Franklin County, Washington; *P.m. bairdii* from Alexander, Iowa; and *P.m. rufinus* from La Veta, Colorado. These subspecies not only come from localities widely separated geographically, but they are very different in body characters, pelage color, and general behavior. The fourth stock in which waltzing arose belongs to a very distinct species, the cactus-mouse, *Peromyscus eremicus eremicus*, our stock of which was taken near Carrizozo, New Mexico.

All of the strains of these mice in which waltzing has appeared had been previously inbred in the laboratory. If we assume waltzing to be a recessive defect already present in the stocks the inbreeding which occurred would be

likely to produce some homozygous individuals. There is no evidence that the mutations causing this defect occurred in the laboratory. The inbreeding of healthy stocks could not itself be the cause of the production of waltzing, for many other lines of *Peromyscus* have been closely inbred for numerous generations without the appearance of the waltzing characteristic.

Waltzing in *Peromyscus maniculatus* has previously been observed by Sumner (1932, p. 9), who found the character in a cross between albino (*P.m. gambelii*) and pallid (*P.m. rubidus* x *sonoriensis*) mutants, but the evidence for the inheritance of the character was "not very strong."

The waltzing behavior of these mice is very similar to that of the well-known domestic waltzing mouse, which belongs to the genus *Mus* and to a different family of rodents than *Peromyscus*. When properly stimulated the waltzing *Peromyscus* tend to run in close circles, often so rapidly that they seem to be rotating on the legs on the inside of the circle. The same mouse may rotate either to the right or to the left. The whirling may be kept up for a half-minute or even more at a time. Frequently the affected mice will waltz in their cages without apparent external stimulation. Being placed in a strange cage or jar, the jangling of keys, or a pinch on the tail will usually stimulate a mouse having the waltzing character to perform his circling motions.

The deer-mice possessing the waltzing defect often have a pronounced trembling of the head associated with a peculiar head posture. These characteristics indicate the defective individuals even before they have performed their circling motions. The defective mice of the species *eremicus* have the most pronounced head movements, but not all individuals which have the trembling of the head can be made to waltz, and one such individual was proved by breeding to be only heterozygous for the waltzing character.

There is considerable variation in the response of different waltzing mice and even the same mouse will react differently on different days. Sometimes a mouse will waltz at once when disturbed, but some mice require long-continued stimulation before beginning to circle. Often a mouse which reacts only after lengthy stimulation will waltz vigorously immediately after the first circles are made, but, on the contrary, some mice can only be induced to make a few circles, even with prolonged stimulation. A mouse which when tested one day is classed as a non-waltzer, may on a later date be induced to waltz, but this is exceptional, and I have tested most of my animals only once.

Older animals are less inclined to waltz than young ones. The mice seem most active at the age of one month, at about which age I have made most of my determinations. However, some individuals, particularly of *bairdii* and of *eremicus*, continue to waltz vigorously at ages considerably over a year.

The difficulty of determining whether any given mouse is a waltzer has probably affected to a slight extent the ratios obtained in the matings described below. The effect of failing to recognize some waltzers would be to make the ratio of waltzers too low and of non-waltzers too high.

The waltzing character is clearly inherited in these mice. It behaves in general as a mendelian recessive. Matings of *bairdii* waltzer X waltzer have produced as offspring 18 male waltzers, 9 female waltzers, and 1 female non-waltzer (expected 28 waltzers). The non-waltzing individual was tested on several occasions at different ages and could never be induced to waltz. She unfortunately died without bearing young. Both her parents were excellent waltzers, as was shown by a check after the finding of their nonconforming offspring. This homozygous individual for some reason failed to show the proper behavior. Matings of *bairdii* waltzers with non-waltzers heterozygous for waltzing produced as offspring 21 waltzers and 25 non-waltzers. This agrees closely with expectation, which, if the character be recessive, is 23 waltzers and 23 non-waltzers.

In the *artemisiae* stock from Lyon's Ferry, matings of waltzer X waltzer produced 7 males and 3 females, all waltzers. Matings of waltzers with non-waltzers of which sibs were waltzers produced 7 male and 6 female waltzers, and 3 male and 3 female non-waltzers. The numbers of young are too small and the genetic constitution of the parents in some cases too uncertain to draw any general conclusion, but the data can be interpreted as agreeing with the hypothesis that the waltzing character in this subspecies is a simple mendelian recessive.

The *rufinus* stock from La Veta had been almost entirely discarded before the waltzing character was discovered, and the remaining animals proved infertile; therefore no ratios are available for this subspecies. The two waltzing individuals found, a male and a female, were brother and sister, which indicates an inherited character.

In the species *eremicus*, matings of waltzer X waltzer have produced 18 male and 12 female offspring, all waltzers. One pair of non-waltzing mice of the same stock produced 22 young, all non-waltzers. The back-cross of waltzers with non-waltzers (but descended from one waltzing parent) has produced 24 male and 23 female waltzers, and 23 male and 28 female non-waltzers. In this back-cross the ratio of waltzers to non-waltzers obtained (47:51) is very close to expectation (49:49).

Out-crosses between *bairdii* waltzers from Alexander, Iowa, stock, and non-waltzers of *bairdii* from Ann Arbor, Michigan, gave 21 young, all non-waltzers. The back-cross between these heterozygous young and waltzers from Alexander stock, gave 17 male and 18 female waltzers, and 37 male and 42 female non-waltzers. There is here a considerable deficiency of waltzers, for the expected ratio is 57 waltzers to 57 non-waltzers, while there was obtained only 35 waltzers to 79 non-waltzers.

A similar out-cross in *artemisiae* also resulted in a deficiency of waltzers in the back-cross. Waltzers of the stock taken at Lyon's Ferry were out-crossed to mice of the same subspecies from Pullman, Washington. The two localities are about 50 miles apart. Fifteen young were produced by the out-cross,

all being non-waltzers. In the back-cross to waltzers of the stock from Lyon's Ferry there were obtained 38 male and 25 female waltzers, to 64 male and 60 female non-waltzers. There were expected, assuming waltzing to be completely recessive, 93.5 waltzers to 93.5 non-waltzers, but there were obtained only 63 waltzers to 124 non-waltzers.

Among the descendants of a cross between a normal *artemisiae* from Pullman and a waltzer from Lyon's Ferry there appeared a psychopathic condition simulating epilepsy, which will be discussed later in this paper. This defect was confined to the offspring of a single pair and none of the epileptic mice are here counted as waltzers, unless they also waltzed, and it is not believed that this character has appreciably confused the ratio of waltzers to non-waltzers above given.

Following the out-crossing of waltzers to stocks from other geographical localities, both in *bairdii* and in *artemisiae*, it will be noted that the ratios of waltzers to non-waltzers is less than in the offspring of pairs not involving an out-cross. This is true notwithstanding the fact that the out-cross was in both cases to mice of the same subspecies and in the *artemisiae* out-cross was between stocks living only 50 miles apart and not separated by a barrier of any apparent kind.

Out-crosses in waltzing domestic mice result in abnormal conditions among the offspring according to McPheters and Little (1933, p. 157), who state that "In waltzing individuals extracted from out-crosses there is much variability in the expression of the abnormality." The abnormalities of heredity which follow out-crosses of waltzers in both *Peromyscus* and *Mus* perhaps have some common basis.

There are considerable differences in the waltzing behavior in the three stocks which I have had under close observation: *artemisiae*, *bairdii*, and *eremicus*. The *eremicus* waltzers are more persistent in the waltzing habit and are easier to stimulate to waltz than either the *artemisiae* or the *bairdii*. All the older *eremicus* seem entirely unresponsive to sounds. The *artemisiae* waltzers are much more sluggish and require more stimulation to be made to waltz than do the *bairdii* waltzers. This probably is correlated with the much greater nervousness and greater activity of all the *bairdii*, both normal and waltzers. However, when the *artemisiae* have been stimulated sufficiently to begin waltzing they may perform as vigorously as do the *bairdii*. Another important difference between these two subspecies of *maniculatus* is that the *artemisiae* waltzers seem to be unresponsive to sounds, except when quite young, while the *bairdii* waltzers of all ages respond to sounds.

Deafness seems always to occur in adults of the domestic waltzing mouse, but Yerkes (1907, p. 90) believes that the young mice, in some instances, hear sounds for a few days during the third week of life, just after the external ears have opened.

It is not at all easy to satisfy oneself either that the waltzing *Peromyscus*

hear or that they are deaf. *P. bairdii* especially is very active and the head is seldom at rest; one therefore cannot always be sure that a movement of the animal is a response to a sound.

When a sharp sound is produced near a resting *Peromyscus* it will nearly always slightly twitch its ears, and the mice respond to rather faint sounds. I have found that the click made by snapping together a pair of forceps will usually produce a response in normal mice. Perhaps a better method of producing a sound is to tap a bottle gently with a pair of forceps or other small piece of steel. The animals are very keen in their senses other than hearing and they respond by sight to movements of the hands of the observer; they detect very slight air currents; and they also notice vibrations of the cage. Therefore, the source of sound must be entirely out of sight of the animals, and be free of contact with the table or cage. I nearly always secure a response in normal *Peromyscus* by snapping a forceps or by striking a bottle held in the hand under the table, using care not to make any movements of the body which might cause a response by the animal.

There are responses to sharp sounds by young waltzers of *artemisiae*, *bairdii*, and *eremicus*, so I feel sure that when young most of these waltzing *Peromyscus* can hear. It is more difficult to determine the responses of the *eremicus* than of the other forms, for they have the habit of crouching motionless with ears pulled down to the head. Nevertheless, I believe that some of the young waltzing *eremicus* can hear, though all of the older waltzing animals are wholly unresponsive to sounds. Some at least of the young waltzing *artemisiae* also respond to sounds, and apparently some individuals retain the ability to hear until they are several months of age, but all the older waltzing animals fail to respond to sounds. The *bairdii* waltzers on the other hand seem to be responsive to sounds throughout life, and I have been unable to find an animal over three weeks of age that fails to give the ear twitch when a sharp sound is produced. Of a pair of waltzing *bairdii* recently tested the female was 1½ years old and the male 2 years. Both gave a definite ear twitch to the sound of a glass bottle struck lightly by a steel forceps. They however did not respond to the sound so vigorously as did young *bairdii* of non-waltzing stock. The bottle was held in such a manner that I feel sure the response was to the sound stimulus alone.

These differences between the characters of the waltzers of the several races of *Peromyscus* indicate the possibility that the waltzing character is not precisely similar in the different subspecies.

A further test of this possibility is furnished by the production of hybrids between *artemisiae* and *bairdii*, both of which are subspecies of the species *maniculatus*. Some difficulty was found in producing hybrids between the waltzers of these two subspecies, for there is a considerable difference in size as well as in behavior between the two forms. I have been able to rear only two hybrids, one male and one female, neither of which shows any tendency

to waltz. When the female hybrid was back-crossed to a *bairdii* waltzing male there were produced two young, one of which was a waltzer and the other a non-waltzer. I take this to indicate that possibly the waltzing defects of *artemisiae* and of *bairdii* are caused by different hereditary factors. If the waltzing genes of *bairdii* and of *artemisiae* were identical we should expect all their offspring to be waltzers.

The waltzing behavior of *eremicus* is so different from that of both *artemisiae* and *bairdii* that probably it is a third gene modification. Unfortunately *eremicus* will not hybridize with any member of the *maniculatus* species, and therefore a test by hybridization is impossible.

Because of the different behavior of the waltzers in the different stocks and because of the apparently different hereditary basis for waltzing in *artemisiae* and *bairdii* it seems necessary to conclude that some or all of the several waltzing strains of *Peromyscus* must have originated independently by parallel mutations.

Epileptic behavior has appeared, as above stated, in four stocks of these mice: in the two deer-mice, *Peromyscus maniculatus artemisiae* from eastern Washington and *P.m. rufinus* from northern Arizona; in the cactus-mouse, *P. eremicus eremicus* from Carrizozo, New Mexico; and in the brush-mouse, *Peromyscus boylii rowleyi*, from the Santa Catalina Mountains, Arizona.

The occurrence of epilepsy in another deer-mouse, *Peromyscus maniculatus gambelii*, has previously been recorded by Sumner (1932, pp. 38–39).

The original animal, a female, almost invariably had a typical epileptic seizure when removed from her cage to a glass battery jar, but outgrew the malady after she was 29 months of age. Several of her offspring showed the character, though to a lesser degree, for considerable auditory stimulation was usually necessary to induce the fits.

In the cactus-mouse *Peromyscus eremicus eremicus*, epilepsy has so far been found only in one individual, which only recently has been discovered in the inbred waltzing strain from Carrizozo. This individual, a young female previously identified as a waltzer, was placed with some of her litter mates in a metal cage strange to her experience. She immediately became excited and started to race about the cage. After racing for perhaps 20 seconds she fell over on her side in an epileptic seizure. While in this condition she made some spasmodic movements of the limbs. In about two seconds she began to recover and started to walk slowly about the cage. She repeated this performance two or more times. It is not yet known whether the epilepsy of this individual is inherited.

In the brush-mouse *Peromyscus boylii rowleyi*, an epileptic seizure was observed by Adolph M. Stebler in an individual of the stock from Summerhaven, in the Santa Catalina Mountains of southern Arizona.

In the deer-mouse *Peromyscus maniculatus rufinus*, epilepsy has been noted also by Stebler, in several brothers and sisters descended from two mice cap-

tured on Deadman Flat in northern Arizona. Waltzing does not occur in this stock, and therefore in this case epilepsy is not associated with waltzing. There is considerable difference in the behavior of these epileptic mice from those of the subspecies *artemisiae* and it is highly probable that in these two subspecies the defect is due to different hereditary characters.

In the subspecies *artemisiae* epilepsy appeared, as above mentioned, among the descendents of an out-cross between waltzers of the stock from Lyon's Ferry and a considerable inbred stock of the same subspecies from Pullman, Washington. A first generation male from this out-cross, and therefore heterozygous for waltzing, was back-crossed to a waltzing female from Lyon's Ferry, and several of the offspring showed distinct psychopathic tendencies. The epileptic character was first noted when a young female, stimulated by the jangling of keys, crouched for a time in one corner of the cage; then, the stimulation being continued, she suddenly began to dash wildly about the cage, bumping against the wire screen of the cage sides and against other objects inside the cage. After a few seconds of this furious dashing about she fell over on her side in an epileptic seizure. The jangling of the keys was immediately stopped, and within a minute the mouse recovered sufficiently to begin walking about the cage. For a minute or so her actions were somewhat sluggish, but her behavior soon became normal.

Possibly the epileptic character was derived from the Pullman stock for it has not been found in the stock from Lyon's Ferry. However, epilepsy was not noted in the non-waltzing Pullman mice, though the stock had been discarded before the importance of making such an observation was realized.

The epileptic mice are in appearance not distinguishable from normal *artemisiae*, but their behavior under certain kinds of stimuli is unusual. The usual stimulus I have employed is auditory, and is produced by the jangling of a set of keys strung on a key-ring. The distance of the keys from the mice varies from near the cage to about five feet away. I find that changes in the distance and in the loudness of the jangling are more likely to induce a reaction than is a constant loudness. Some mice respond nearly at once; others require several minutes of auditory stimulation before reacting; and probably some affected individuals fail to respond at all and thereby escape detection.

The most characteristic reaction of the epileptic mice is the race about the cage. This is usually preceded by the animal's taking a crouching position in one corner of the cage soon after the sound stimulus is initiated. However, the duration of the crouch is variable, and seemingly may sometimes be omitted. In the crouching position the affected mouse appears unusually tense, the nose is elevated and the ears are drawn back. Some mice which do not race and are apparently normal will pull back their ears much like the affected mice. Therefore it is not safe to assume that every mouse which crouches is epileptic.

The race about the cage begins very suddenly, almost like an explosion.

During the race the animal is obviously not in full control of its movements, for while normal deer-mice are very agile in avoiding objects when running at full speed, the racing mouse strikes objects and the sides of the cage with considerable force.

An epileptic seizure may or may not follow the race about the cage. Some mice will race for several minutes, if the sound stimulus be continued, without ever passing into an epileptic state. Other individuals have an epileptic seizure after only a moment of racing.

The severity of the epileptic seizure also varies greatly. Usually the mouse falls over on its side motionless except for very rapid breathing. The rate of breathing is most rapid when there has been a prolonged period of racing. In a few cases there have been spasmodic movements of all four limbs; occasionally the mouth is opened widely; and rarely coarse squeaks are produced. When taken into the hand the epileptic mouse is limp and there is no detectable muscular rigor. I have always discontinued the sound stimulus as soon as the mouse has an epileptic seizure. The mouse recovers within a few seconds or at most a half-minute. It immediately starts to walk about the cage, but the first movements are not well coördinated and the mouse staggers somewhat. It remains sluggish and its movements are rather stiff for a minute or two, after which it seems to be entirely normal.

One female died during an epileptic seizure. She had received lengthy stimulation by the jangling of keys as well as by the presence of other psychopathic mice in the same glass cylinder. She crouched for a long time, suddenly raced for a moment, and then fell over on her side in an epileptic seizure, dying immediately.

Both males and females suffer from the defect and I have been unable to discover any difference between the sexes in the behavior of the affected mice.

That racing and epilepsy are closely associated is apparent, for practically all the epileptic mice race for at least a short time before having the epileptic seizure. I have therefore classed all individuals which race as epileptics, which I feel sure they are, potentially. However, numerous individuals which race vigorously never have an epileptic seizure, even after prolonged stimulation and prolonged racing.

There is some evidence that in these mice the waltzing character is separate genetically from the epileptic character. Many waltzing *Peromyscus maniculatus artemisiae* have shown no evidence of epilepsy; also many of the epileptic mice have shown no tendency to waltz. However, the same animal may possess both tendencies, as has been noted in a number of individuals. For example, a litter of 6 young *artemisiae*, both parents being heterozygous for epilepsy, was made up of 1 male and 1 female epileptic and 4 apparently normal offspring. All these young when about 4½ weeks old were placed together for observation in a tall glass battery jar. Under the stimulus of the unusual situation some kept jumping up toward the top of the jar a little

more actively than normal mice of the subspecies would have done. At a distance of 5 or 6 feet I began gently jingling a bunch of keys. One young female began to jump vigorously toward the top of the jar, then suddenly dropped to the floor of the jar and waltzed rapidly for a few seconds, after which she began to run and jump wildly about the cage, terminating in a few seconds by falling over on her side breathing rapidly but otherwise immobile. I stopped jingling the keys and picked her up in my hand. In a few seconds she began to recover, but it was perhaps a minute before she was able to walk, and for a few minutes she was seemingly somewhat stiff and sluggish. The defective male of the same litter, when stimulated by the jingling of the keys, raced rapidly about the jar, but did not waltz or become immobile.

The defective behavior of these mice from eastern Washington is definitely inherited, and is certainly recessive to normal behavior. Epileptic males mated to normal females from a stock from Palouse Falls, taken only about 6 miles from where the stock from Lyon's Ferry was secured, and not known to carry tainted heredity, produced 15 normal offspring. Back-crosses of these normal but heterozygous offspring with epileptic males have produced 48 offspring, of which 12 were epileptic, 3 were waltzers, and 33 were normal in behavior. Assuming epilepsy and waltzing to be separate mendelian characters not linked in heredity, there should have been 24 epileptic offspring, instead of 12. The deficiency may possibly be due to some effect of the outcross in which the stock originated. We found above that following an outcross there is a deficiency in the number of waltzers obtained, and possibly the epileptic character here under consideration may have been affected in a similar direction.

From matings between F_1 heterozygous mice, from the above described matings, there have been obtained 74 offspring, of which 7 were epileptic, 5 were waltzers, 8 were epileptic and waltzers, and 54 were normal. Again assuming that epilepsy and waltzing are independent and that both parents were heterozygous for waltzing as well as for epilepsy, there would be expected 13.9 epileptics, 13.9 waltzers, 4.6 showing both epilepsy and waltzing, and 41.6 normals. It will be observed that the numbers of epileptics and of waltzers obtained were approximately half of the expected numbers, while the number combining waltzing and epilepsy is about double the expectation. This may indicate some tendency for the association of the epileptic condition with waltzing. However, the numbers are too few to be of much statistical significance.

A number of pairs of epileptic individuals have so far failed to produce offspring. From a mating of an epileptic female and a waltzing male which was the son of an epileptic father, there were obtained as offspring, 6 epileptics and 1 waltzer. Assuming, as we must if the two characters are independent, that the epileptic female was heterozygous for waltzing, and that the waltzing male was heterozygous for epilepsy, the expected young should have been

1.75 epileptics, 1.75 waltzers, 1.75 showing both epilepsy and waltzing, and 1.75 normal. The great preponderance of epileptics and the lack of any normals indicates the possibility that in these mice waltzing and epilepsy are more or less associated in heredity.

That epilepsy may be associated with waltzing in other stocks of *Peromyscus* is indicated by the finding of the epileptic individual above mentioned in the waltzing strain of *eremicus*.

Although there is thus some indication of an association in heredity between waltzing and epilepsy, much further work will be necessary to determine the relationships of the two characters. It is entirely possible that waltzing, whatever may be its association with epilepsy, is primarily a nervous defect, rather than a morphological defect of the semicircular canals or any other part of the inner ear, as has been commonly assumed.

The epileptic *artemisiae* strain has been unusually fertile in my laboratory, producing somewhat larger and more frequent litters than unaffected strains of this sub-species. This increase in fertility may possibly be due in part to the out-cross involved in the origin of the stock, rather than to an effect of the defective heredity. However, it is obvious that the presence of the hereditary defect has not in any way reduced the fertility of the stock.

Judging from the number of cases already known of the independent occurrence of recessive hereditary defects of behavior among the different species and subspecies of *Peromyscus*, we are justified in assuming that hereditary defects of behavior must be widespread among the wild mice of this genus.

SUMMARY

Waltzing, an hereditary defect, appeared at the University of Michigan independently in four different inbred stocks of *Peromyscus*, representing two subgenera. Three of the stocks belong to different subspecies of a deer-mouse, *Peromyscus maniculatus*; the other stock belongs to the cactus-mouse, *Peromyscus eremicus*.

The waltzing character is inherited in general as a simple mendelian recessive to normal behavior. One homozygous individual failed to exhibit the character and there is considerable variability in the type of waltzing response. Following the out-crossing of waltzers to other stocks of the same subspecies, the offspring show a deficiency in the expected number of waltzers.

The different waltzing strains differ somewhat from one another in the character of the defect. Waltzing *bairdii* apparently are never deaf while the waltzing *artemisiae* and *eremicus* when old do not respond to sharp sounds.

Crosses between *bairdii* waltzers and *artemisiae* waltzers produced 2 non-waltzing offspring. This possibly may indicate that the waltzing defects in the two subspecies are produced by different hereditary factors.

Epilepsy has appeared in a waltzing stock of *Peromyscus maniculatus artemisiae*, following an out-cross. In this stock of mice epilepsy is recessive in inheritance to normal behavior.

Epilepsy has also been found in one other subspecies of deer-mouse, *Peromyscus m. rufinus*, in a waltzing strain of the cactus-mouse, *P. eremicus eremicus*, and in the brush-mouse, *P. boylii rowleyi*; but it is not certainly known that the epilepsy of any of these mice other than *artemisiae* is inherited.

Waltzing and epilepsy in these mice are probably due to different hereditary characters, but there is some indication that in the deer-mouse the two characters may be sometimes associated in inheritance.

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DERMATOGLYPHICS IN TUPAIA LACERNATA LACERNATA

By Charles Midlo

Through the kindness of Dr. William L. Straus, Jr. of the Johns Hopkins Medical School, the writer had the opportunity to study the volar surfaces of the manus and pes of a preserved specimen of *Tupaia lacernata lacernata* (U. S. National Museum, no. 123989, ♀). In view of the writer's interest in the comparative study and phylogeny of epidermal ridges, he feels particularly fortunate to record these features in a representative of a genus that many authorities consider the prototype of all higher placental mammals.

Figure 1, *A*, presents the volar aspect of the right manus of *Tupaia lacernata lacernata*. In addition to the thenar and hypothenar pads, the four typical mammalian interdigital pads are present. The hypothenar pad is the largest, and, similar to interdigital pads *II*, *III*, and *IV*, possesses the form of a low, irregular, three-sided pyramid. In these four pads the apices and rounded edges are covered with short, usually slightly curved, ridges placed transversely with respect to the direction of the edges. Considerable portions of the sides of the pads are devoid of ridges. However, were one to continue the ends of the transversely placed ridges across the bare areas there would result a pattern of concentrically arranged ridges covering the pad. The pattern would then simulate successive spherical waves with the center of disturbance situated in the apex of the pad. Thus the arrangement of the epidermal ridges on the pads considered may be said to satisfy the fundamental plan of the mammalian dermatoglyphic pattern system which desider-

ates whorl-like patterns at their phylogenetic inception (Whipple, 1904; Midlo, 1930).

Interdigital pad *I* and the thenar pad differ from the other pads of the vola in their shape and conformation of ridges. Both of these pads are elongated, ridge-like elevations in which the rounded crest and the greater parts of the slopes possess parallel, slightly curved ridges placed transversely to the long axis of the pad. Interdigital pad *I* of the left manus differs slightly in its dermatoglyphic expression as compared to the same pattern of the right

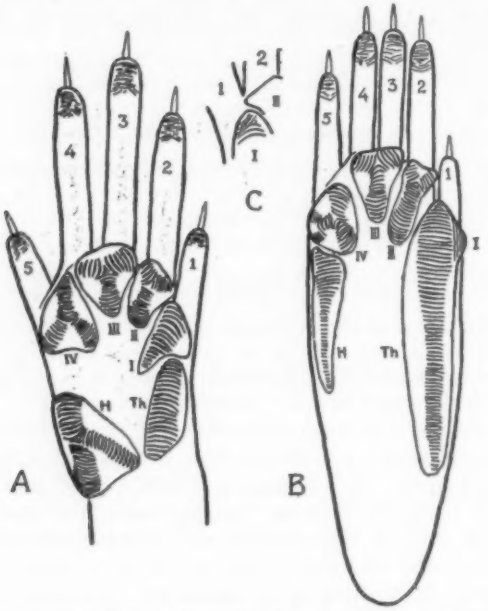

FIG. 1. *A*, epidermal ridges of right manus; *B*, epidermal ridges of right pes; *C*, disto-radial margin of vola of left manus; *1–5*, digits; *I–IV*, interdigital pads and patterns; *H*, hypothenar pad and pattern; *Th*, thenar pad and pattern.

manus. In the former the distal portion of the pad (fig. 1, *C*) evidences an arrangement of ridges which approaches somewhat the condition noted in the other interdigital patterns.

In the manus, the volar surface of all distal phalangeal segments shows an area covered with short, transversely coursing ridges bounded proximally, on each side of the digit, by a few ridges running in an oblique, proximal, and lateral direction. In this connection it may be stated that apparently the transverse direction of the ridges on the apical pads is not a constant feature in

Tupaia, for Wood Jones (1929) depicts the apical pads of the right manus of *Tupaia ferruginea* covered with longitudinal ridges.

The plantar surface of the pes (fig. 1, *B*) is characterized by five walking pads. Interdigital pad *I* and the thenar pad are fused into one long, ridge-like mound which is almost half the sole length. The distal portion of the fused pad is wider than the proximal segment, which gradually tapers to terminate in a rounded point. Approximately seventy transverse ridges cover the rounded crest of the pad, the slopes being largely bare. Distally the ridges are longer than in the proximal part. On the tibial margin of the wider distal portion several longitudinally directed ridges are noted, very probably a rudiment of the first interdigital pattern complex.

The hypothenar pad is an elongated ridge situated near the fibular margin of the planta, parallel to the thenar pad. The crest of the pad is covered with about forty transverse ridges.

The second and third plantar interdigital pads partake of the same featural characters as those of the manus, both in general form of the pad and in the arrangement of the dermatoglyphics.

Interdigital pad *IV* has the form of a low, irregular, four-sided pyramid. The four edges are crossed by ridges which in their entirety evidence the incipient whorl element typical for the basic mammalian determatoglyphic pattern.

The ventral aspects of the distal pedal phalangeal segments of digits *2* to *5* are covered largely with groups of transversely directed ridges, proximally to which are noted several obliquely directed ridges. On the ventral aspect of digit *1* of the pes, no ridges were found. Wood Jones pictures, however, longitudinally striated apical pads on all digits of *Tupaia ferruginea*.

Bimanual and bipedal variations in dermatoglyphics are insignificant in the specimen studied. They largely concern a slight increase or decrease in the ridge number. Except as noted, the configurations of epidermal ridges of the left manus and pes are gross mirror images of the dermatoglyphics pictured in the accompanying illustration.

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FUNCTIONAL ADAPTATIONS IN THE FORELIMB OF THE SLOTHS

By Ruth A. Miller

The correlation of locomotor habits and of the morphological structures concerned with such habits, or the old question of structure and function, continues to offer interesting problems for the investigator. Each animal species is adapted to its particular environment by certain structural peculiarities, the inheritance of which has enabled the line to survive. The course of the evolutionary trend of these adaptations is often very difficult to recognize, especially in some of the more highly specialized forms. As Gregory points out, the various modern species are the result of adaptive radiations along different lines, starting from a common primitive undifferentiated stem form. According to their individual needs, the members of each family are adapted to the environment, some species having gone much farther along their particular line of specialization than others. These specializations may take place in any or several systems of the body, the most obvious being those in the anatomical structures that make up the locomotor apparatus.

One of the most interesting families from the point of view of functional adaptations is the one which comprises the sloths. These animals have departed far along their line of specialization from the undifferentiated stem type. The present paper attempts to correlate the morphology of the upper extremity of these species with the use to which it is put during locomotion. As a criterion of comparison, the tree shrew is chosen because of the generalized character of its extremities and its unspecialized type of locomotion.

Classification of the species studied

Order Edentata
Suborder Xenarthra
Superfamily Bradypodoidea
Family Bradypodidae
Genus *Bradypus* (species, *tridactylus*)
Choloepus (species, *didactylus*)
Order Insectivora
Superfamily Tupaioidea
Family Tupaiidae
Genus *Tupaia* (species, *picta*)

The above classifications are according to Simpson ('31).

The dissections were checked as far as possible with those of other workers, notably Lucae ('84) and Meinke ('10) for the sloths, and Clark ('24) for the tree shrew.

The animals dissected were from the collections of the College of Physicians and Surgeons. The American Museum of Natural History permitted the study of the skeletal material. The Primates used comprised specimens

acquired by the African Anatomical Expedition of Columbia University and the Museum.

LOCOMOTOR HABITS OF THE SPECIES

Of all mammals the sloths have probably the strangest mode of progression. The two-toed species spends most of its time in the trees, hanging with the back downward from the under side of the branches. It rarely descends to the ground and then moves with the greatest difficulty because of the peculiar conformation of its extremities. As an adaptation for its locomotor habits, the limbs terminate in two hook-like digits with thick calloused palmar pads and long curved claws. There is little provision for the use of the hands as such; the extremities are held in a fairly fixed position by the terminal hooks. The active movements of the limbs, however, involve a considerable amount of motion at the shoulder and wrist, since the animal must reach about in all directions as it swings from branch to branch. When the sloth progresses through the trees, it moves with great deliberation, using the four limbs alternately. Consequently, its mode of progression is similar to that of an arboreal quadruped, except that the body is held in the reversed position. Anthony (1907) finds the positions of the limbs during locomotion similar to those in a trotting animal.

The three-toed sloth is not so extreme in its habits as its two-toed relative. Although the animal progresses in the reversed position, when feeding, it may squat in the angle of a branch and reach about with its hooked appendages, which lack the palmar callouses. This animal also sleeps in a squatting position with the head upon the chest and the arms folded over the body (Wislocki, '28). There is more discrepancy in the proportions of its extremities, the forelimb being much longer than the hindlimb, whereas those of the two-toed sloth are more equal in length.

The tree shrew is an interesting "control" specimen for the specialized locomotor types just described. It is a primitive little animal with a non-prehensile tail, possessing the necessary locomotor apparatus in a generalized form. The various members of the family are arboreal in habitat, although they readily descend to the ground, where they hop about on all fours with the long tail held up in the air. In the trees they run along the branches and jump from limb to limb, clinging with the grasping feet very like squirrels. When resting or feeding they show a further resemblance to the rodents by sitting on the haunches and grasping the food between the forefeet. In general, the upper extremity exhibits the variety and range of movement that are characteristic of arboreal quadrupeds (Miller, 1932).

STRUCTURAL ADAPTATIONS OF THE SPECIES STUDIED

Tupaia

As a generalized type, the tree shrew possesses morphological characteristics that are found with some variation in most of the less specialized mammals. For the sake of clarity, therefore, the following descriptions are given in outline form, stressing the characteristics most significant from the point of view of locomotor adaptations. Other works should be consulted for more detailed accounts.

MUSCULATURE

The muscles of the upper extremity fall naturally into four groups: (1) the shoulder group, comprising those supporting the clavicle and scapula; (2) the arm group, those moving the humerus at the shoulder joint; (3) the forearm group, those acting upon the forearm through the elbow and radio-ulnar joints; and (4) the hand group, comprising the long muscles of the digits and those which control the wrist joint.

1) Shoulder musculature:
   - trapezius without the clavicular insertion
   - omocervicalis present
   - rhomboideus with the origin from the occiput to the upper thoracic vertebrae
   - occipitoscapularis present
   - levator scapulae with a single head
   - serratus anterior with cervical and thoracic divisions
   - subclavius well developed
2) Arm musculature:
   - "common pectoral" (Huntington, '03) present
   - pectoralis major with a few fibers of origin from the clavicle
   - pectoralis minor inserting upon the head and neck of the humerus
   - pectoralis abdominis present
   - latissimus dorsi extending far caudally
   - spino-humeralis present (Clark, '24)
   - teres minor lacking
   - deltoideus in three parts with a wide origin from the clavicle (the spinal part considered the teres minor by Clark)
   - supraspinatus wider than the infraspinatus
   - coracobrachiales superficialis, medius, and profundus present (Howell and Straus, '31)
3) Forearm musculature:
   - brachialis arising from the lateral surface of the humerus
   - triceps with a fourth head, the origin of the long head extended along the scapula
   - dorsoepitrochlearis with an extra origin from the teres major and an insertion over the forearm fascia
   - pronator teres with a single humeral head
   - supinator with a single humeral head
4) Hand musculature:
   - flexor digitorum sublimis with origins from the humerus, ulna, and palmaris longus and three tendons of insertion, fused with the profundus at the wrist
   - flexor digitorum profundus with humeral, ulnar, and radial heads
   - extensores carpi radialis longus and brevis a single muscle with a double insertion
   - extensor digitorum communis well developed
   - extensor digiti quinti with tendons to the fourth and fifth digits
   - extensores pollicis longus and indicis proprius a single muscle with tendons to the first three digits
   - extensor pollicis brevis slight

SKELETON

A brief description of the bony framework of the upper extremity is necessary in order to understand the mode of attachment of the muscles and the type of action which they are capable of producing.

- clavicle slender and curved
- scapula narrow and elongated along its glenovertebral axis
- supra- and infra-spinous fossae of approximately equal size
- humeral head rounded and directed backward at a right angle to the transverse plane of the condyles (Miller '32)
- forearm slightly longer than the arm

radius and ulna partially fused at their distal extremities
five subequal digits with curved claws
naviculare and semilunare fused into a scapho-lunar bone
os centrale present

Bradypodidae

As closely related species and as examples of similar locomotor adaptations, the sloths present an interesting series of comparisons in the morphology of the upper extremity. For the sake of convenience in study, the structural characteristics of the two are described in parallel sections. Furthermore, only those characteristics are dealt with which vary from the general type as exemplified by *Tupaia*.

Bradypus

1) Shoulder musculature:
   - trapezius thoracic in origin, wide clavicular origin
   - omocervicalis lacking
   - rhomboideus thoracic in origin
   - occipitoscapularis lacking
   - levator scapulae lacking
   - serratus anterior thoracic in origin
   - subclavius inserting also upon the coracoid and acromial processes
2) Arm musculature:
   - common pectoral present
   - pectoralis major without a clavicular origin
   - pectoralis minor inserting upon the head of the humerus
   - clavobrachialis present
   - supra- and infra-spinatus of nearly equal size
   - teres major inserting with the latissimus dorsi
   - teres minor present
   - deltoideus restricted in its clavicular origin
   - coracobrachialis medius present
3) Forearm musculature:
   - biceps with glenoid and humeral heads, inserting upon the radius and ulna
   - brachialis incorporated with the humeral portion of the biceps
   - brachioradialis in two parts, inserting also over the wrist
   - triceps three-headed, with the origin of the long head slightly from the scapula
   - dorsoepitrochlearis with an insertion upon the humeral condyle
   - pronator teres inserting upon the radius with the brachioradialis
   - pronator quadratus small
4) Hand musculature:
   - palmaris longus inserting also upon the carpal bones
   - flexor carpi radialis to the radial carpals and metacarpal
   - flexor carpi ulnaris inserting upon the carpal bones
   - flexores digitorum sublimis and profundus fused into a single muscle
   - extensores carpi radialis longus and brevis a single muscle, inserting with the brachioradialis and upon the radial carpal bones
   - extensor carpi ulnaris to the fourth metacarpal
   - extensor digitorum communis to the three digits
   - extensor digiti quinti lacking
   - abductor pollicis longus to the radial carpal bones
   - extensores pollicis longus and brevis lacking
   - extensor indicis proprius to the second and third digits

Choloepus

1) Shoulder musculature:
   - trapezius with a high vertebral origin, a few fibers to the clavicle
   - omocervicalis present
   - rhomboideus with occipito-cervical and thoracic divisions
   - occipitoscapularis well developed
   - levator scapulae with a single head
   - serratus anterior with cervical and thoracic divisions
   - subclavius inserting also upon the coracoid and acromial processes
2) Arm musculature:
   - common pectoral lacking
   - pectoralis major in three parts, no origin from the clavicle, one tendon of insertion with that of the biceps
   - pectoralis minor in two parts, inserting upon the head of the humerus
   - clavobrachialis present
   - supraspinatus larger than the infraspinatus
   - teres major inserting with the latissimus dorsi
   - teres minor lacking
   - deltoideus restricted in its clavicular origin
   - coracobrachialis medius present
3) Forearm musculature:
   - biceps with a single glenoid head, inserting upon the radius and ulna
   - brachialis inserting with one tendon of the biceps
   - brachioradialis in two parts, inserting also over the wrist
   - triceps three-headed, the origin of the long head extended along the scapula
   - dorsoepitrochlearis with an insertion upon the humeral condyle
   - pronator teres inserting upon the radius with the brachioradialis
   - pronator quadratus large
4) Hand musculature:
   - palmaris longus with the flexor digitorum sublimis tendons to the digits
   - flexor carpi radialis to the radial carpal bones
   - flexor carpi ulnaris in two parts, one of the insertions with the brachioradialis
   - flexor digitorum sublimis from the ulnar portion of the flexor digitorum profundus, inserting with the palmaris longus
   - extensores carpi radialis longus and brevis a single muscle, with an extra origin from the radius and a double insertion
   - extensor carpi ulnaris to the ulnar carpal bones
   - extensor digitorum communis to the two digits
   - extensor digiti quinti to the third metacarpal
   - abductor pollicis longus to the radial carpal bones
   - extensores pollicis longus and brevis lacking
   - extensor indicis proprius to the second digit and the first metacarpal

Bradypus

- nine cervical vertebrae, fourteen rib-bearing thoracic vertebrae
- clavicle occupying half the distance between the scapula and sternum, the interval being completed by a ligament
- scapula with an oblique shape, the inferior angle acute and the spine directed upward
- acromion reduced, clavicle articulating with the coracoid process

supra- and infra-spinous fossae of approximately equal size
humerus long and straight with slight prominences, the condyles wide and flat
humeral head small and round, at the end of the shaft on a level with the tubercles
forearm slightly longer than the arm
radius and ulna widely separated
second, third, and fourth digits functionally developed, with long hook-like claws
first and fifth metacarpals vestigial
naviculare and greater multangular coalesced (greater multangular and head of the first metacarpal, according to Flower, '70)
capitate and lesser multangular coalesced
proximal phalanges ankylosed with the metacarpals

Choloepus

seven cervical vertebrae, twenty-four rib-bearing thoracic vertebrae
clavicle well developed, attached to the sternum by a long ligament
scapula with an oblique shape, the inferior angle acute and the spine directed upward
acromial and coracoid processes elongated and coalesced, forming a scapulo-coracoid foramen
supraspinous fossa larger than the infraspinous
humerus long and straight with slight prominences, the condyles wide and flat
humeral head small and round, at the end of the shaft on a level with the tubercles
forearm longer than the arm
radius and ulna separate
second and third digits functionally developed, with long hook-like claws
first and fourth metacarpals vestigial, the fifth lacking
naviculare and greater multangular coalesced
capitate and lesser multangular coalesced
proximal phalanges short and independent

FUNCTIONAL ADAPTATIONS OF THE SPECIES

Tupaia

The type of locomotion exhibited by a species may be directly correlated with the morphology of the parts employed. As a primitive arboreal quadruped, the tree shrew possesses a generalized type of upper extremity, which is capable of producing a variety of motions.

The arrangement of the shoulder musculature (fig. 1) is such as to give strong craniad and medial support to the scapula by the trapezius and rhomboid-levator elements, as well as a steadying forward and downward action by the serratus anterior and subclavius. The arm muscles flex and extend the shoulder joint, according to their location, as they alternately place the limb in a supporting position and propel the trunk forward. The differentiation of the pectorales and the widespread latissimus dorsi with its extra division, the spino-humeralis, are of distinct advantage in lifting the trunk forward and upward against gravity, as is necessary in arboreal locomotion. The extensive coracobrachiales aid the pectorales in their adducting action upon the arm. The large deltoideus and supraspinatus raise the arm forward, while the scapula is being steadied by the shoulder muscles. Because of the relative size and position of the teres minor-infraspinatus elements and the subscapularis, however, little rotary action of the shoulder joint is possible. The main purpose of these muscles is to steady the head of the humerus in the glenoid cavity.

The forearm muscles are well adapted for the flexion and extension of the elbow joint

necessary in quadrupedal progression. The extensor group is stronger than the flexor. The presence of the dorsoepitrochlearis, the "climbing muscle," is noteworthy; it serves to coördinate the actions of the teres major and latissimus dorsi upon the arm with that of the triceps upon the forearm. The pronators of the forearm are relatively stronger than the supinator and hold the hand in a constantly pronated position, so that very little rotation of the radius takes place (fig. 1). A certain amount of pronation and supination is made possible by the forearm muscles which act upon the wrist and oppose the palms sufficiently for the animal to grasp food between them. The position and structure of the hand musculature is significant of the arboreal type of quadrupedism. Here also the extensor group of muscles is stronger than the flexor. This is especially noticeable in the long muscles of the digits. Little individual finger action is possible, however, because of the fusion of the various muscles and the subsequent divisions of their tendons of insertion. The fingers can be moved enough to grasp branches as the animal progresses or to hold objects as it feeds.

As far as the skeleton is concerned, the form and position of the bones are such as to facilitate arm movements in an antero-posterior direction with a limited amount of lateral range. The elongated scapulae are placed vertically upon the sides of the narrow thorax, with the glenoid fossae directed downward. Such a condition combined with the backwardly directed head of the humerus tends to limit the movements of the shoulder joint to flexion and extension. The length of the clavicle, however, has some effect upon increasing the range of motion of the arm by supporting the glenoid cavity more laterally. The rounded head of the humerus, which moves within the glenoid fossa, is also a factor in the increased freedom of the shoulder joint. The length of the forearm particularly is an arboreal characteristic, which gives increased leverage to the flexors and extensors of the elbow. The coalescence of the radius and ulna, however, greatly limits the range of the pronating and supinating movements of the hand. Wrist motions are also somewhat restricted by the fusion of the carpal bones. The presence of an os centrale is usually considered a primitive character.

Bradypodidae

The shoulder musculature (fig. 1) of the two species of sloths presents an interesting comparison in locomotor possibilities. In *Bradypus* the muscles are almost entirely lacking in cranial and cervical attachments and are reduced to the minimum necessary for support of the shoulder girdle. Consequently in this species the pull exerted by the shoulder musculature is medial rather than craniad. Through the situation of its fibers the trapezius especially exerts a very important action upon the clavicle. The muscles of *Choloepus*, on the other hand, are so placed as to offer the greatest possible support dorsally and ventrally to the head as well as to the scapula. Thus the muscle action is concentrated on a craniad as well as a medial pull upon the shoulder girdle. This is obviously correlated with the animal's mode of progression in the reversed position with the head hanging downward. *Bradypus*, as may be inferred from its musculature, adopts this posture less frequently and spends much time with the head dropped forward upon the chest. The medial pull of the dorsal group of muscles is of course balanced by that of the serratus anterior in a lateral direction. The action of the former group is stronger, however, to offset the tendency toward lateral displacement of the scapula coincident with the support of the body by the arms. The very strong subclavius of both species with its scapular insertion is necessary for reinforcement of the ligamentous sternal extremity of the clavicle.

The arm group of muscles offers more points of similarity in action between the two species. In general those of *Bradypus* afford the wider range of action and those of *Choloepus* more coördination. The three-toed sloth can swing its body around from a

suspended to a sitting position, which necessitates extensive muscle action from the arms upon the trunk. The wide and varied pectoralis group of the two-toed species keeps the arms strongly adducted to the body and exerts an action with the biceps in flexion of the forearm. The large pectorales and latissimus dorsi (together with the teres major) are strong agents in advancing the trunk when the body is suspended by the limbs. The clavobrachialis is a muscle peculiar to both species. It strengthens the restricted attachment of the deltoid upon the vestigial clavicle and coördinates the adducting pull of that portion of the muscle with the flexing action of the biceps. The presence of the teres minor in the three-toed sloth argues for more freedom of action at the shoulder joint than that possessed by the two-toed. In the former species also the clavicular attachment of the trapezius and in the latter the large supraspinatus help to continue the forward and outward movement of the arm. The coracobrachialis medius in both species supports the head of the humerus in the glenoid cavity against outward pull when the animal is suspended by the limbs. Generally speaking, the

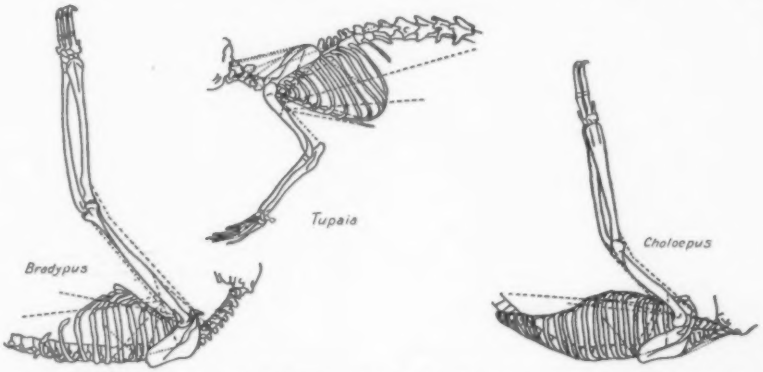

FIG. 1. Direction of pull of the muscles of the shoulder group (dotted lines), the arm group (dashes), and the dorsoepitrochlearis of the forearm group (dots and dashes).

arm muscles of the sloths are adapted for adduction and flexion at the shoulder joint, together with a forward pull upon the body. This condition is a check upon the tendency toward abduction and extension necessitated by the suspended position.

The two- and three-toed sloths are very much alike in the adaptations of their forearm musculature. The main points of difference between the two are in connection with the more constantly suspended position of the two-toed species. In this animal the single-headed biceps is concerned as much with supporting the head of the humerus in the shoulder socket as in flexion of the elbow. The insertion of the muscle in both animals favors direct flexion of the forearm without supination. By its palmar insertion the brachioradialis prolongs its flexing action from the elbow to the wrist and aids in supination of the hand. The forearm flexor group in both species is closely bound together and stronger in concentrated action than the extensor. Of the latter group the dorsoepitrochlearis is not necessary as a climbing muscle and has no extending power upon the elbow joint, but helps to further the adducting action of the latissimus-teres muscles upon the distal extremity of the humerus. By its lengthy insertion the pronator teres greatly increases its range of flexing ability and is an effective balance to the brachioradialis. In the forearm of the sloths the pronating and supinating muscles

very successfully check each other. The biceps has no supinating action, while that acquired by the brachioradialis is offset by the pronator teres. This condition is better developed in *Choloepus* than in *Bradypus*. As a whole, the forearm musculature of the sloths is adapted for flexion of the elbow and a half pronation-half supination of the wrist (fig. 2). This state of development is necessary to balance the extreme extension of the forearm when the animal is hanging by the extremities. A considerable amount of flexibility at the wrist is essential, as the hand must assume various positions in reaching from limb to limb.

The most interesting muscular adaptations of the sloths are of course to be found in those of the abbreviated hand structures. Here the flexors of the digits are the stronger group; the extensors exert their greatest action upon the wrist. There is little provision for individual finger action; the tendons supplying the digits are either lacking or closely fused together both dorsally and ventrally. The insertions of the

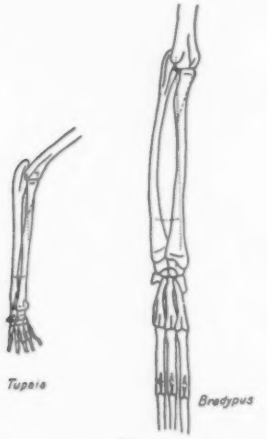

FIG. 2. Direction of pull of the pronators (dotted lines) and supinator (dashes) of the hand.

muscles of the fingers and wrist are strikingly modified to correspond with the changes in the bones of these parts. Muscles inserting upon the metacarpals in other animals here have attachments upon the carpals. Those to the fifth or fourth metacarpals now insert upon the fourth or third, as the case may be. Those to the phalanges of the missing digits are notably absent. In the sloths the main purpose of the hand musculature is to keep the wrist firmly braced in extension and the digits fixed in flexion. These are the muscles that insure the hook-like character of the manus.

A skeletal condition to be noted in connection with the upper extremity of the sloths is the number of cervical and thoracic vertebrae and ribs. These bones offer an extensive area of attachment for the muscles which support the shoulder girdle, and when the shoulder is fixed, for those which pull the body forward. It is a striking fact that no shoulder muscles attach upon the elongated cervical column of *Bradypus*, so that in this respect the head is poorly supported. *Choloepus*, especially, offers a great thoracic area for the action of the shoulder muscles upon the trunk. In either animal support

by muscular attachment upon the clavicle is of course very limited. The reduced condition of this bone also does not allow for much widening of the thorax through lateral displacement of the scapulae, which are placed on the sides of the trunk as in the ordinary quadruped. One of the most important skeletal adaptations of the sloths is the obliquely shaped scapula with the upwardly directed spine. The shape of the bone offers more space for attachment of the supporting shoulder muscles and gives the arm muscles an increased angle of leverage. The position of the glenoid fossa in conjunction with that of the head of the humerus produces a shoulder joint admirably fitted for action when the body is suspended by the limbs. The modified coracoid-acromion adds needed strength to the acromio-clavicular articulation and an extra area of attachment for the subclavius muscle. The length of the arm and forearm bones also provides for greater power and extent of action on the part of their muscles. In any type of "brachiation" the ordinary points of leverage are reversed. The longer forearm becomes the fixed lever, and its muscles are great factors in raising the body. This is especially evident in *Bradypus* and may be correlated with the animal's ability to swing itself to a sitting position. Pronation and supination of the hand is facilitated by the separation of the radius and ulna, a condition which offers wider space for muscle action. In the sloths these movements take place as the suspended animal passes from limb to limb during locomotion or reaches about in search of food. Structurally the skeleton of the hand offers practically no opportunity for individual muscle action. The separate phalanges give the manus of *Choloepus* an extra joint for grasping which is not possessed by *Bradypus*. It is interesting to note that the flexor muscles to the more rigid digits of *Bradypus* are not differentiated into the usual superficial and deep layers with insertions upon separate phalanges. The main purpose of the hand bones is to make the manus a very effective hook, by which the sloths can hang from the branches.

DISCUSSION

The sloths are unique among mammals in their mode of progression. They can hardly be termed arboreal quadrupeds, as their quadrupedism is of the reversed or suspensory type. In this respect they may be compared with the lower Primates, the lemurs and certain of the Old World monkeys. These animals can walk along the upper or the under side of a branch with equal ease. There is a very close resemblance among arboreal quadrupeds in the morphology of the upper extremity, irrespective of family relationships. The opossum, the tree shrew, and the lemur possess common characteristics indicative of a certain amount of freedom in the use of the shoulder and wrist joints, which are to be correlated with an arboreal existence. The sloths, however, exhibit a somewhat modified type of arboreal locomotion in that they move almost entirely along the under side of the branches, hanging suspended by the hook-like extremities. This can in no sense be compared with brachiation. The movements are extremely sluggish; the animal swings slowly along from one branch to the next, always hanging by the four extremities. Nothing could be more remote from the lightning-like speed of the typical brachiator, as it flings itself from limb to limb, catching and swinging by the arms alone. Even the squatting position of *Bradypus* is not like that of the lower monkeys. The sloth requires the support of the angle of a limb in order to maintain its balance if the arms are used for other purposes. Monkeys, on the other hand, can sit with the back erect and the shoulders braced. The ability of the arboreal monkeys to progress easily over the flat ground cannot of course be attained by the highly specialized sloths.

However limited their mode of locomotion may be in comparison with that of the Primates, the sloths exhibit interesting structural adaptations which are similar in

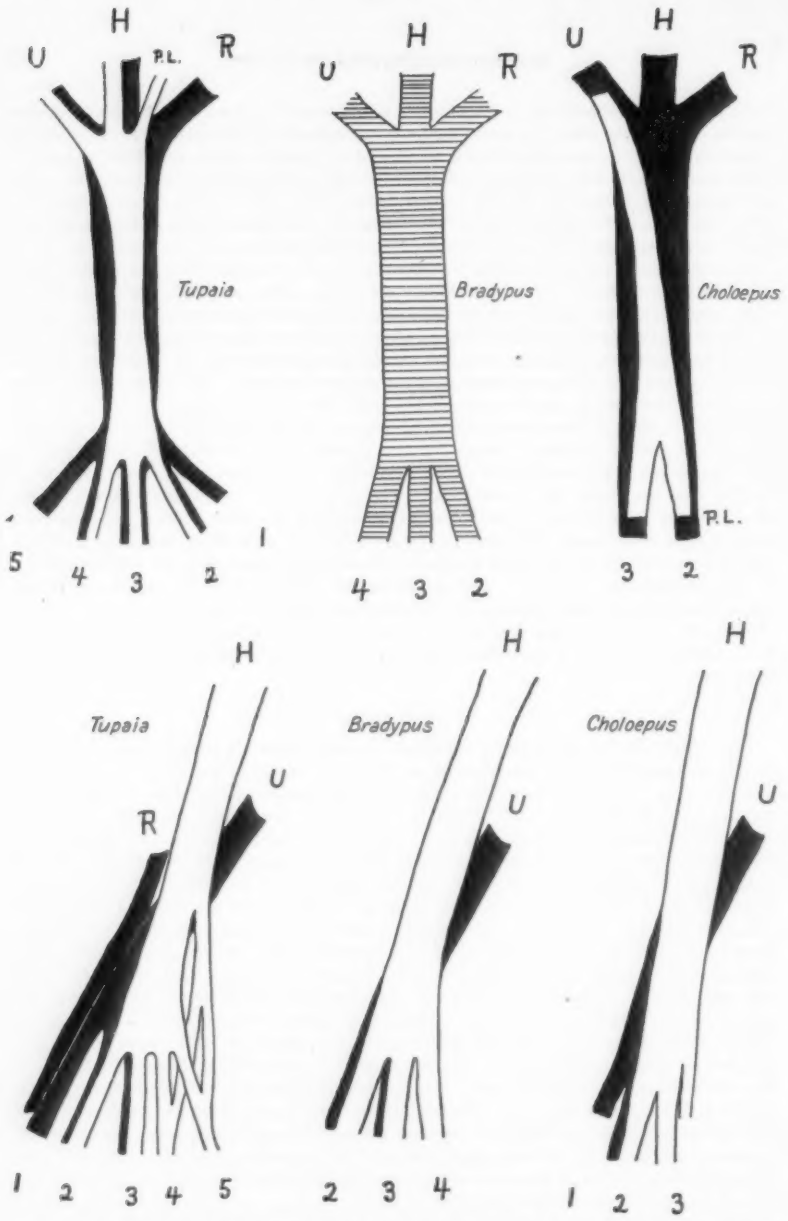

FIG. 3. Upper row. Diagram of the long flexor muscles of the digits (deeper muscles shaded). *P.L.*, palmaris longus; *U*, ulna; *H*, humerus; *R*, radius.

Lower row. Diagram of the long extensor muscles of the digits (deeper muscles shaded). *U*, ulna; *H*, humerus; *R*, radius.

many respects to those of the monkeys and even of the apes. These adaptations are to be correlated with similar habits of the animals in swinging the body about by the arms. The reduplication and coalescence of muscles, especially in *Choloepus*, resemble conditions which exist in the gibbon and which facilitate coördination of muscle action. The oblique shape of the scapula in the sloths is similar to that of the gibbon, as is the relation of the rounded head of the humerus to the glenoid cavity, which makes for freedom of action in the shoulder joint. The position of the scapulae upon the dorsal surface of the widened thorax and the correlated pull of the scapular muscles, which produce the orthograde shoulder posture of the apes is conspicuously absent in the sloths. In the latter species the pull of the dorsal scapular muscles is directed toward the prevention of lateral displacement of the shoulder girdle. The lengths of the arm and forearm bones with their consequent leverage actions may also be compared with those of the monkeys and apes. The separation of the radius from the ulna and its free motion about the latter bone are comparable in the sloths and Primates. The ability to pronate and supinate the hand is a great point of similarity between the two groups of animals. Indeed, Lucae ('84) finds that the sloths are equal if not superior to the monkeys in the extent of action of the joints of the upper extremity.

In the hand, however, the similarities between the sloths and other mammals cease. The long flexor and extensor muscles of the digits, expecially, offer many interesting points of contrast with other animals. The tree shrew possesses a very primitive type of flexor mass, which exhibits about as much differentiation as that of the opossum (according to McMurrich's classification) (fig. 3, *Tupaia*). The flexors of the sloths, on the other hand, are even more primitive than these and show practically no differentiation into superficial and deep parts (fig. 3). From the lemurs through the monkey groups the sublimis and profundus components become more and more distinct. In the higher apes the profundus is further differentiated into pollicis and digitorum portions. Dorsally the extensor muscle mass shows a similar series of distinctions among the various species. In the opossum and tree shrew the extensor tendons are not specific for the pollex and the digits, but supply them indiscriminately, fusing and dividing again into roughly medial and lateral groups (fig. 3, *Tupaia*). In the lemur these divisions become more distinctly pollicis-indicis on the radial side and digiti quinti on the ulnar. The extensors of the thumb are particularly well developed in the monkeys and apes. The sloths, however, have a sorry complement of extensor muscles (pl. 3, figs. 4 and 6). The pollicis and digiti quinti elements are lacking or have moved their insertions to the metacarpals, and the remaining tendons to the digits cannot be differentiated. Thus it may be seen that the rigid appendage of the sloth cannot be compared with the grasping hand of the Primates. The apes indeed possess a hand with greatly elongated digits and a shortened thumb, which is used in a hook-like fashion during brachiation. The muscles, however, are highly differentiated, and the finger joints are capable of a great degree of action. The entire appendage is an extremely mobile organ capable of unlimited action and not a mere mechanism for suspending the body.

From the above descriptions it is evident that the sloths combine a type of arboreal quadrupedism with certain features suggestive of the locomotion of the higher monkeys. The muscular and skeletal adaptations of the upper extremity reflect the peculiar locomotor habits of the species in a combination of primitive and highly specialized characteristics.

SUMMARY

1. The sloths exhibit a peculiar type of arboreal quadrupedism, in which the animal progresses almost entirely in a suspended position with the back downward.

2. The three-toed species differs from its two-toed relative in its adaptations for a kind of squatting position with the arms free rather than for continuous suspension by the four extremities.

3. The tree shrew is a good example of a generalized arboreal quadruped, with which the specialized sloths may be compared.

4. In *Tupaia* the elongated scapulae are situated upon the sides of the narrow thorax, and the backwardly placed humeral head articulates with the downwardly directed glenoid cavity. Thus the shoulder and arm muscles can produce motions of the upper extremity mainly in an antero-posterior direction with a limited amount of lateral range.

5. The extensor muscles of the elbow, wrist, and digits are better adapted for locomotion than are the flexors.

6. Little supination of the hand is possible in the tree shrew because of the coalescence of the radius and ulna and the predominance of the pronator muscles.

7. The hand is a generalized structure with enough finger action to enable the animal to grasp branches or to hold food between the opposed palms.

8. In the Bradypodidae the scapulae are obliquely shaped, with the glenoid directed upward. This in conjunction with the rounded head of the humerus produced a shoulder joint capable of a wide range of motion. The pull of the shoulder muscles is for strong medial support of the shoulder girdle.

9. The arm muscles are so arranged upon the scapula as to give the adduction and flexion of the shoulder joint necessary for locomotion in a suspended position. At the same time their attachments upon the greatly elongated thorax exert a powerful forward and upward pull upon the body.

10. In the forearm of the sloth the flexors of the elbow and extensors of the wrist are adapted for suspension of the body by the arms. The pronators and supinators are well balanced and, acting in conjunction with the widely separated radius and ulna, allow for much freedom of motion of the hand at the wrist.

11. The hand is a rigid book-like appendage with the two or three digits fixed in flexion and incapable of individual action.

12. The sloths resemble the monkeys and even the apes in certain muscular and skeletal adaptations of the upper extremity for a type of locomotion in which the body is suspended by the arms.

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GRAVIGRADE SLOTH REMAINS FROM THE LATE PLIOCENE AND PLEISTOCENE OF IDAHO

By C. Lewis Gazin

Paleontological exploration for the U. S. National Museum in southern Idaho during the summers of 1929 and 1930 by the late Dr. J. W. Gidley, with Mr. C. P. Singleton as assistant, resulted in the uncovering of several important occurrences of fossil vertebrates. Leads to these finds were furnished by Dr. H. T. Stearns of the U. S. Geological Survey and Mr. Elmer Cook of Hagerman, Idaho. Of especial importance is the late Pliocene occurrence in the vicinity of Hagerman, which has produced a variety of vertebrate forms, including an abundance of material representing *Plesippus shoshonensis*.

The sloth remains obtained at Hagerman consist of mandible and foot material representing the extinct genus *Megalonyx*. Specimens from various localities in the vicinity of Hagerman were collected by Gidley and Cook in 1929 and 1930, and by Mr. S. P. Welles in 1930. A mandible portion was discovered in the *Plesippus* quarry during excavation of the equid material in 1931 by Mr. N. H. Boss.

A mammalian assemblage distinctly later than that at Hagerman and clearly of Pleistocene age was encountered by Gidley and Singleton in gravel beds near American Falls, Idaho. Among the mammalian forms identified in this fauna are horse, camel, deer, bison, musk-ox, mastodon, mammoth, sloths, carnivores, and rodents. Most of the sloth material obtained belongs to *Megalonyx*, although a few specimens are found to represent *Paramylodon*. No remains recognized to be *Nothrotherium* were discovered in the collections from the Idaho region.

An early record of the occurrence of edentates in beds exposed in the Snake River basin of Idaho is that of "*Morotherium*" *leptonyx* Marsh (1874, p. 532). The type of this species is a claw, which, according to Hay (1927, p. 9), was the specimen mentioned by Leidy in 1871 (p. 365) and recorded by him as coming from Castle Creek, Owyhee County. Castle Creek is some distance west of Hagerman and the beds in this vicinity are those which Cope named the Idaho formation. In 1902 (p. 56), I. C. Russell reported the finding of a toe bone, which Lucas identified as *Morotherium*, in beds exposed in Little Valley, near Bruneau, Idaho.

The generic name *Morotherium* was proposed by Marsh (1874, pp. 531–532) for the species *M. gigas*, based on an incomplete femur and humerus from the Pleistocene of California. It is improbable that the form is generically distinct from some one of the better known gravigrade sloths of North America, but the femur, later designated as the type, is apparently not adequate to establish its relationship. The claw[1] from the Idaho beds which

[1] I was unable to examine this specimen, as Dr. Thorpe informs me it has been mislaid.

Marsh made the type of a second species, *M. leptonyx*, presumably is also inadequate for generic or specific diagnosis. However, it seems probable that in this case a small species of *Megalonyx* is represented, as no determinable material of other genera of ground sloths[2] is known from these beds. Hence, the megalonychid material from Hagerman is tentatively referred to this species.

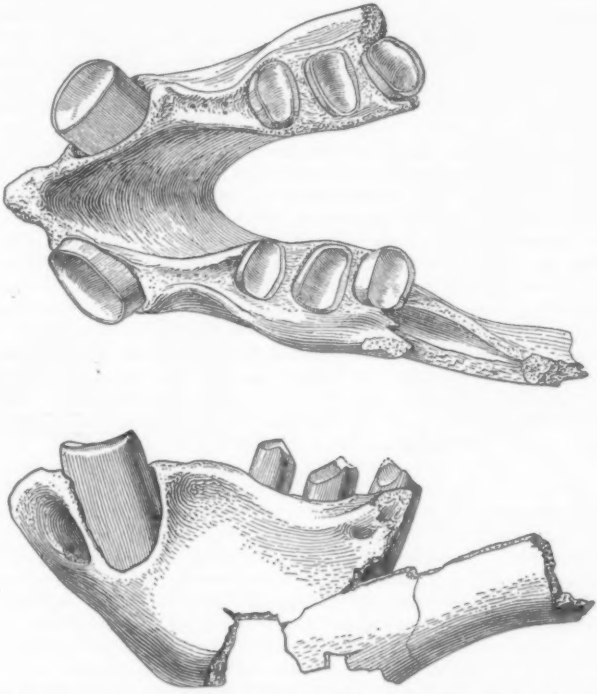


FIG. 1. *Megalonyx leptonyx*? (Marsh). Mandible, no. 13477, U. S. N. M., lateral and occlusal views. ×½. Hagerman lake beds, Upper Pliocene, Idaho. Drawing by Sydney Prentice.

Megalonyx leptonyx? (Marsh)

Material.—Included in the megalonychid remains from the Hagerman lake beds is an imperfect mandible, no. 13477, U. S. Nat. Mus., with a complete lower dentition

[2] There is a remote possibility that the specimen is from a chalicothere, in which case it may have come from the Miocene Payette beds of the region; however, in Marsh's description no mention is made of a cleft or division of the ungual and a sheath is definitely indicated, suggesting sloth.

(fig. 1), found about six miles south of the *Plesippus* quarry. Associated with it were an upper caniniform tooth (fig. 2, *a*), an upper cheek-tooth (fig. 2, *b*), a claw and patella. A second specimen belonging to a smaller and apparently more immature individual, no. 12669, U. S. Nat. Mus., comprises the greater portion of both mandibular rami, and is edentulous except for the left caniniform tooth. This specimen and two proximal phalanges were taken from the horse quarry. An isolated last upper molar (fig. 2, *c*), a co-ossified trapezium and first metacarpal (fig. 3), two fourth metacarpals (fig. 4), a claw and several tow bones were obtained at various localities south of the quarry.

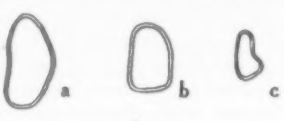
Description.—Marsh's original description for the type of this species is as follows: "*Morotherium leptonyx*, sp. nov.—A smaller species [than *M. gigas*], apparently of the same genus, is indicated by some fragmentary remains, the most characteristic of which is an ungual phalanx of the third digit of the fore-foot. This resembles most nearly in form the corresponding bone in *Megalonyx jeffersonii* Harlan, but differs from it in the much less developed ungual sheath, and in the presence of a large rounded tubercle on the lower side, instead of a flat basal plate. The articular facets are quite unequal, the inner being considerably larger and deeper than the outer. The ridge between them is obtuse. The ungual sheath has its greatest development on the inner side. There is a large vascular foramen on the outer side at the base of the tubercle, and on the opposite surface this is replaced by several smaller orifices. This phalanx, when entire, was about 90 mm. in length. It is 42 mm. in vertical diameter through the basal tubercle, and 24 mm. wide across the articular facets. The specimen was found in the Pliocene beds of Idaho, and has been kindly loaned to me for examination by my friend, Prof. J. S. Newberry, of Columbia College."

The Hagerman material indicates a distinctly small species as compared with the known forms in the Pleistocene. It is much smaller than *Megalonyx jeffersonii* and appreciably smaller and shallower jawed than *Megalonyx wheatleyi* Cope (1899, pp. 212–217). The lower caniniform tooth (fig. 1) is transversely compressed, moderately curved, and exhibits a nearly flat lingual surface as compared with *M. wheatleyi*. The anterior portion is slightly more compressed than the posterior half. The lower molars are similar to those of *M. wheatleyi* but are somewhat more rounded in cross-section. The outline of the first molar in occlusal view, though well rounded, approaches a trapezoid. The anterior and posterior surfaces are nearly parallel but the inner and outer portions converge anteriorly. The outline of the second molar in occlusal view tapers lingually, but is less angular than in *M. wheatleyi*. The last lower molar has its external surface somewhat less rounded than the lingual portion and there is a slight longitudinal groove on the outer half of the posterior surface. All three molars are worn so that the highest point of the crown is at the antero-lingual margin, and with the postero-external portion elevated, but to a less extent. The upper caniniform tooth (fig. 2, *a*) is well curved, as in *M. wheatleyi*, but in cross-section the lingual convexity is much more subdued and there is a more distinct medial concavity or groove on the external surface. The upper molar (fig. 2, *b*) belonging to no. 13477 is apparently second or third in the cheek tooth series. The posterior surface of this tooth is nearly flat and the anterior surface convex. The greatest anteroposterior diameter is across a distinctly lingual part of the tooth.

An isolated last upper cheek tooth (fig. 2, *c*), no. 13568, U. S. Nat. Mus., from near Hagerman presumably represents *Megalonyx* although the groove on the posterior surface appears more deeply impressed than in the various figures of this tooth observed in the literature. The tooth is of relatively small size and what is apparently the outer portion has a much greater anteroposterior diameter than the lingual half.

The foot element identified as a fused trapezium and first metacarpal (fig. 3) is comparatively large, nearly as large as in the Pleistocene mylodonts of Rancho La Brea. The proximal articulating surface for the scaphoid appears elongate dorso-ventrally and concave transversely. The long axis of this surface lies nearly in the plane of the

keel on the distal articulating surface. The keel or carina is distinctly set off from the inner portion of the articulating surface for the first digit and extends well back on the ventral surface of the bone. The inner side of the carina is less clearly defined. The proximal or trapezial portion of the fused bone extends dorsally and outward toward the second metacarpal and on the outer side of this projection is a nearly plane, oval facet for articulation with the second metacarpal. The co-ossified first metacarpal and trapezium measures 42 mm. from proximal surface to distal extremity of carina, and is 44 mm. wide across the proximal portion.



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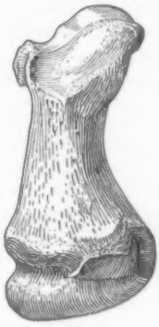

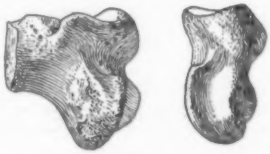

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FIG. 2. *Megalonyx leptonyx*? (Marsh). *a*, upper caniniform tooth; *b*, upper cheek tooth; no. 13477, U. S. N. M. *c*, Last upper molar, no. 13568, U. S. N. M. Occlusal views. ×½. Hagerman lake beds, Upper Pliocene, Idaho. Drawing by Sydney Prentice.

FIG. 3. *Megalonyx leptonyx*? (Marsh). Co-ossified trapezium and first metacarpal, no. 13570, U. S. N. M., dorsal and lateral views. ×½. Hagerman lake beds, Upper Pliocene, Idaho. Drawing by Sydney Prentice.

FIG. 4. *Megalonyx leptonyx*? (Marsh). Fourth metacarpal, no. 12675, U. S. N. M., lateral and proximal views. ×½. Hagerman lake beds, Upper Pliocene, Idaho. Drawing by Sydney Prentice.

The fourth metacarpals from Hagerman closely resemble this element in *Megalonyx jeffersonii* as illustrated by Leidy (1855, pl. 10, figs. 6, 11, 12) but are about three-fourths as large. In specimen no. 12675 (fig. 4), the proximal portion appears relatively shallow dorso-ventrally and the distal end relatively deep. In no. 12674, the ends are more nearly proportioned as in Leidy's figure, but the shaft is relatively more robust. In lateral view the profile of the proximal end of the fourth metacarpal is roughly S-shaped with the ventral portion strongly convex. On the inner side of the proximal end the greater part of the facet for articulation with the third metacarpal is slightly convex in no. 12675, although in no. 12674 it is distinctly concave dorso-ventrally. The facet for the fifth metacarpal is strongly concave. The proximal facet articulating with the

unciform makes an obtuse angle with the facet for the third metacarpal and an acute to nearly right angle with the facet for the fifth metacarpal. The carina on the distal end is strongly developed and articulation was not carried beyond this portion except to a small angular ventro-internal offset, and possibly to a similar dorso-external offset although the latter portion is not well preserved on the two Hagerman specimens. Fourth metacarpal, no. 12675, is 99.5 mm. long and measures about 37.5 mm. across the proximal end dorso-ventrally. The greatest distance across the distal end is 49.5 mm.

Remarks.—Other occurrences of *Megalonyx* in the Pliocene of North America are few and in all instances the material is very incomplete. Cope (1893, pp. 49–51) described fragments of a skull, including an upper molar tooth from the Blanco formation of Texas, which he named *Megalonyx leptostomus*. In Cope's illustrations of this material the alveolus of the upper caniniform tooth is shown as having a strong, rounded postero-internal angle. This outline does not conform to the lingual margin of the upper caniniform tooth from Hagerman, which is more evenly rounded postero-internally. Matthew, in 1924 (pp. 149–150), described a last lower molar from the upper Snake Creek zone in Nebraska, which he made the type of *Megalonyx curvidens*. This tooth is slightly smaller than the posterior molar in the Hagerman specimen, and shows a distinct curvature not seen in no. 13477. In 1906 (pp. 65–66), Sinclair described an edentate claw believed to have come from the Mascall Miocene, but since regarded as having come from the overlying Rattlesnake beds which are of Middle or Lower Pliocene age. This specimen was given the designation *Sinclairia oregoniana* by Ameghino. Its relationships are not clearly determinable although it probably belongs to the megalonychid group. A small claw in the Hagerman collection, of which the sheath is entirely broken away, equals in size and bears a close resemblance to the Oregon specimen.

A review of the Pliocene sloth occurrences of the Pacific region was made by Stock (1925, pp. 18–21), and in addition to the Rattlesnake material fragmentary specimens representing megalonychid forms are recorded from the Pinole Tuff-Orinda-Siesta deposits in middle California and from the San Timoteo and Eden beds in southern California. Particular interest is attached to the Eden occurrence (see Frick, 1921, pp. 349–350) in the finding there of a tooth apparently referable to *Nothrotherium* or a closely allied form.

Megalonyx cf. jeffersonii (Desmarest)

Sloth material from gravel deposits near American Falls, Idaho representing *Megalonyx* includes portions of two mandibles, a scaphoid bone (fig. 6), third metatarsal, a claw apparently belonging to the third digit of the pes and several phalanges. One of the mandibles (fig. 5) consists of the greater portion of the left ramus with a complete dentition. The second lower jaw is more fragmentary and includes only the anterior portion of the left ramus, exhibiting the first cheek tooth and the alveolus for the caniniform tooth.

The material indicates a species of large size and is apparently referable to *Megalonyx jeffersonii*. The more complete mandible, no. 13474, U. S. N. M., is slightly smaller than the specimen described and figured by Leidy (1855, pp. 13–15, pls. 1, 5). The symphysial portion of the jaw from American Falls is robust and projects a greater distance anterior to the caniniform tooth than in Owen's specimen, but the distance between the caniniform tooth and the first cheek tooth is appreciably less, and the superior margin of the jaw between these teeth is not so convex dorsally in a lateral view as in Leidy's figure. The second mandible portion, no. 13475, is apparently more immature, and exhibits an even shorter diastema between the caniniform tooth and the first cheek tooth. The symphysial portion of this jaw is distinctly shallower and does not project so far anterior to the caniniform tooth as in no. 13474, although the teeth were fully as large.

The teeth in the American Falls form correspond closely in size to those in the specimen figured by Leidy but occupy a shorter space in the mandible, as they do in the immature lower jaw belonging to the type of *Megalonyx sierrensis* Sinclair (1905, pp. 155–

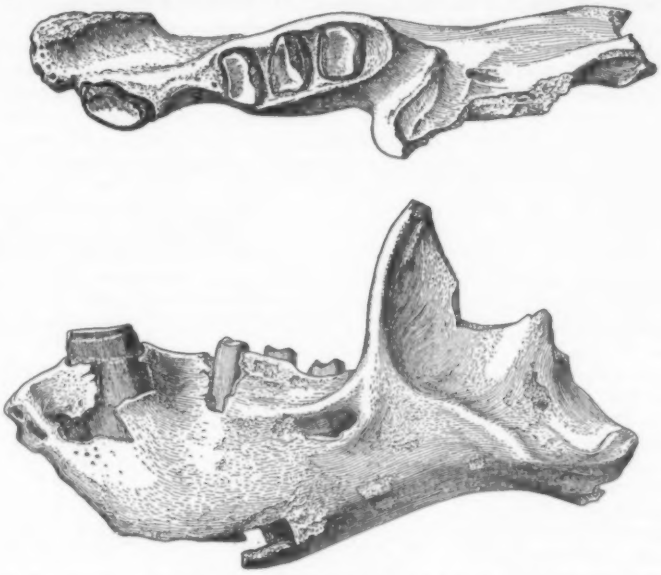

FIG. 5. *Megalonyx* cf. *jeffersonii* (Desmarest). Left ramus of mandible, no. 13474, U. S. N. M., lateral and occlusal views. ×½. American Falls, Pleistocene, Idaho. Drawing by Sydney Prentice.

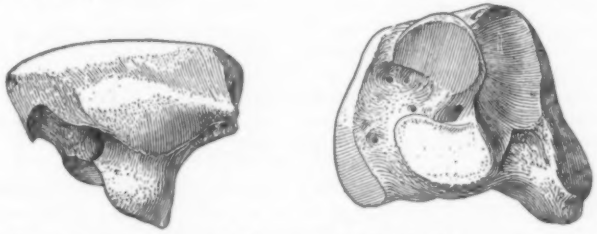

FIG. 6. *Megalonyx* cf. *jeffersonii* (Desmarest). Scaphoid bone, no. 13571, U. S. N. M., dorsal and distal views. ×½. American Falls, Pleistocene, Idaho. Drawing by Sydney Prentice.

160). The lower caniniform tooth resembles markedly the corresponding tooth figured by Leidy (1855, pl. 14, figs. 4–5) as *Megalonyx dissimilis*, regarded by Cope as a variant of *M. jeffersonii*. This tooth appears distinctly larger than in *M. sierrensis*. The lower cheek teeth are more angular than in Leidy's figures of *M. jeffersonii*, than in Stock's

(1925, pl. 17) figures of *M. jeffersonii californicus*, or than in the type of *M. sierrensis*. The first of the three cheek teeth exhibits a groove on the lingual surface and the anterior wall is slightly concave as seen in the dorsal view. The last two molars show a broad but very shallow groove on the buccal surface. The postero-external angle of the last molar is prominently developed.

The *Megalonyx* scaphoid (fig. 6) appears to be a little larger than the one figured by Leidy (1855, pl. 8, figs. 6A–8A) as *Megalonyx jeffersonii*, corresponding more nearly in size to the scaphoid of *Paramylodon* from Rancho La Brea. In proximal view the sur-

TABLE 1

Comparative measurements (in millimeters) of mandibles and teeth

	MEGALONYX LEPTONYX (?) NO. 13477 U. S. N. M.	MEGALONYX CF. JEFFERSONII NO. 13474 U. S. N. M.	MEGALONYX CF. JEFFERSONII NO. 13475 U. S. N. M.
Length of mandible from symphysis to angle		*a* 300	
Length of symphysis	81.2	*a* 120	*a* 92
Distance from anterior projection of symphysis to anterior margin of alveolus for caniniform tooth	*a* 25	38.5	*a* 25
Distance from anterior margin of alveolus for caniniform tooth to posterior surface of last molar	*a* 110	132	
Distance from anterior surface of first cheek tooth to posterior surface of last cheek tooth	*a* 54	66.0	
Length of diastema between caniniform tooth and first cheek tooth	28.0	35.0	*a* 30
Anteroposterior diameter of lower caniniform tooth	30.0	35.8	*a* 35
Transverse diameter of lower caniniform tooth	14.5	16.7	*a* 17.5
Anteroposterior diameter of first lower cheek tooth	14.0	16.5	*a* 17.0
Transverse diameter of first lower cheek tooth	19.2	25.6	24.5
Anteroposterior diameter of second lower cheek tooth	14.0	17.3	
Transverse diameter of second lower cheek tooth	20.5	26.5	
Anteroposterior diameter of third lower cheek tooth	16.0	18.2	
Transverse diameter of third lower cheek tooth	18.5	24.7	
Anteroposterior diameter of upper caniniform tooth	29.1		
Transverse diameter of upper caniniform tooth	15.5		
Anteroposterior diameter of second or third upper cheek tooth	14.0		
Transverse diameter of second or third upper cheek tooth	21.0		

a = approximate.

face for articulation with the radius is expanded dorso-ventrally more than appears in Leidy's figure. In dorsal view the surface for the radius extends out on to the dorsal surface and dorso-internally is approached very closely by the deeply impressed trapezoid surface, as seen in *Megalonyx sierrensis* (Sinclair's pl. 20, fig. 7). In *Paramylodon* the surface for the trapezoid is well separated from that for the radius. The more dorsal of the two magnum facets meets the trapezoid surface distally in a very acute angle. In distal view the surface for the trapezoid is elongate dorso-ventrally and meets the facet for the trapezium ventro-internally at almost a right angle.

In *Paramylodon* these are distinctly separated. Ventro-externally the trapezoid surface joins the inner margin of the lower facet for the magnum in an obtuse angle. In Leidy's specimen these two surfaces are separated by a gutter which extends completely across the distal surface of the scaphoid. In the Idaho specimen the gutter extends from the lunar side only as far as the median dorsoventral ridge. This gutter, however, affects a complete separation of the two facets for the magnum. In *Paramylodon* the surface for the magnum is not divided. The long diameter of the surface for the trapezoid and that of the combined facets for the magnum are nearly parallel, whereas in *Paramylodon* they appear to be at right angles. The greatest length of the scaphoid from the ventro-internal projection to the dorsal margin of the lunar facet is 85 mm. The greatest width across the surface for the radius is 77.5 mm.

The third metatarsal is equal in size and does not differ in any important respect from that of *M. jeffersonii californicus* Stock (1925, p. 107, fig. 48). The facet for the second metatarsal is slightly convex and the surface for the external cuneiform is constricted at the middle as in that form, however, the surface for articulation with the fourth metatarsal appears to be placed slightly closer to the body of the bone. The offset on the inner side of the distal articulating surface is large but the dorsal portion is not developed to the extent seen in the figured specimen from Rancho La Brea. Also,

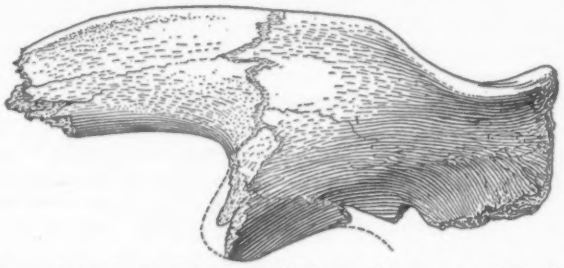

FIG. 7. *Paramylodon harlani*? (Owen). Right jugal bone, no. 13476, U. S. N. M., lateral view. ×½. American Falls, Pleistocene, Idaho. Drawing by Sydney Prentice.

the ventral portion of the carina apparently does not project so far posteriorly. The length of the third metatarsal from mid-point of surface for the external cuneiform to the distal margin of the carina is 53 mm. The greatest depth of the proximal portion is about 65.7 mm. and the greatest width of the proximal portion is 62.5 mm. The dorso-ventral extent of the carina is 75.5 mm.

Paramylodon harlani? (Owen)

Representing *Paramylodon* (see Brown, 1903, and Kraglievich, 1928) in the American Falls collection are an incomplete malar or jugal bone (fig. 7), an unciform and an ungual phalanx. The descending or suborbital process of the jugal is broken away but a sufficient portion of the bone remains to distinguish it from that of *Megalonyx*. The superior margin does not exhibit the sharply rising postorbital process seen in *Megalonyx leidyi* Lindahl (1893, pl. 1–5) or as described by Cope (1899, pp. 214–215) for *Megalonyx wheatleyi*, but the bone extends posteriorly as a deep bar over the squamosal with an inferior branch, not completely preserved, extending a short distance under the zygomatic process of the squamosal. The jugal is comparable to that of *Paramylodon harlani* from Rancho La Brea, as illustrated by Stock (1925, pl. 24), but is apparently somewhat deeper and more robust. The depth of the jugal above the anterior extremity of the zygomatic process of the squamosal is about 44 mm.

The unciform from American Falls referred to *Paramylodon* is clearly distinguished from this bone in *Megalonyx* in the strong development of the proximal knob formed by the surfaces for articulation with the lunar and cuneiform, and in the simple, well-separated facets on the inner side for articulation with the third metacarpal. The specimen corresponds closely in size and form to an unciform of *Paramylodon* from the Pleistocene deposits at Christmas Lake in south-central Oregon, being a little larger than the average for this element in the Rancho La Brea material. The greatest length of the American Falls unciform from the knob to the distal extremity is approximately 88 mm.

The ungual phalanx is of small size, about 80 mm. long, and lacks the sheath, exhibiting a large subungual tubercle. The distal portion of the claw is rounded but with the ventro-lateral surface somewhat flattened. The claw has a noticeable lateral curvature and is slightly concave dorsally. The phalanx may be from the first digit of the right manus or possibly from the second digit of the pes.

Cope, in 1878 (p. 385), described an ungual phalanx from Fossil Lake, Oregon, to which he gave the name *Mylodon sodalis*. This name has since been regarded as synonymous with *Paramylodon harlani*. However, Stock (1925, pp. 196–197) suggests that the greater size of the south-central Oregon sloth may warrant recognizing it as a distinct subspecies. Should this procedure be followed the large size indicated by the very incomplete remains from American Falls further suggests that the Idaho mylodont should be grouped tentatively with the central Oregon sloths as *Paramylodon harlani sodalis*.

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U. S. National Museum, Washington, D. C.

AN IMMATURE MASTODON FROM THE OGALLALA PLIOCENE

By Curtis J. Hesse

There are few accounts of the occurrence, as fossils, of very young or foetal mammals. The two specimens described in the following report I regard as being extremely young because they are smaller than similar forms which are believed to be foetal.

The two specimens represent some member of the family Mastodontidae, but it is not possible to identify the genus, owing to their immaturity. They were collected in the summer of 1931, by a field party of the Museum of Paleontology of the University of Kansas, at the type locality of the Ogallala formation, near the town of Ogallala, Nebraska. With these two fragments was a small, typically Pliocene fauna, made up of the following forms: *Hypolagus, Mylagaulus, Dipoides,*? *Osteoborus, Felis, Teleoceras, Neohipparion, Calippus, Prosthennops,* and *?Blastomeryx.* This faunal assemblage is most closely allied to the Beecher Island fauna (Wray beds) of Colorado, and the Hemphill faunas (Hemphill beds) of Texas. It may be regarded as Middle Pliocene in age (from an unpublished manuscript, by the writer, in the hands of the State Geological Survey of Kansas).

The first of these two specimens (fig. 1) is the posterior part of the right maxillary, with two teeth in place. The most anterior of these two teeth has lost its crown, and might easily be mistaken for a heavily worn tooth, because its surface is flat and presents no characters. The posterior tooth has a well developed crown, with its anterior inner tip broken away. This tooth is placed at an angle of almost 45 degrees with the mid-line of the jaw, and it slightly overlaps the posterior outer margin of the anterior tooth. The angle of this tooth with the mid-line, and the fact that the anterior inner base projects through the wall of the jaw, leads one to believe that the specimen may be abnormal. The pattern of the cusps on this second tooth resembles in a general way that of the other members of the family Mastodontidae from the same horizon. In measurements it is approximately one half the size of the foetal *Platybelodon grangeri*, recently described by Osborn and Granger (1932, p. 5).

The second specimen (fig. 2) is a superior milk incisor of an animal of the same family, although there is no evidence that both specimens are parts of the same individual. The incisor is oval in cross section, becoming flattened at its root. The anterior tip is coated with enamel, which fades away one fourth of the distance from tip to base. The tip is slightly curved downward, and at the base of the enamel cap, on the inner side, there is a worn spot. The tip is blunt and the mark of wear is quite pronounced. It seems impossible to explain this wear on any other grounds than that of use of the tooth, and this makes it unlikely that the individual was foetal. The incisor corresponds in detail to the figures of a similar tooth given by Osborn and

Granger (1932, p. 5, fig. 3A). The two Nebraska specimens average about one half the size of the Chinese specimen, which has been considered as foetal;

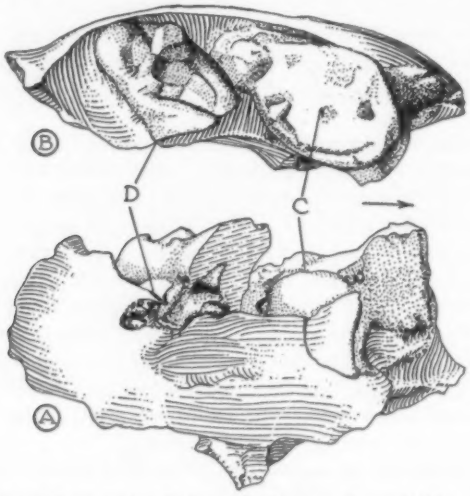

FIG. 1. Right maxillary, natural size. *A*, Inner or buccal side. *B*, Crown view. *C*, Flattened area due to absence of crown of anterior tooth. *D*, Point at which the tip of posterior tooth projects through the inner maxillary wall. Arrow indicates anterior. No. 3758, Mus. Paleont., Univ. Kansas.

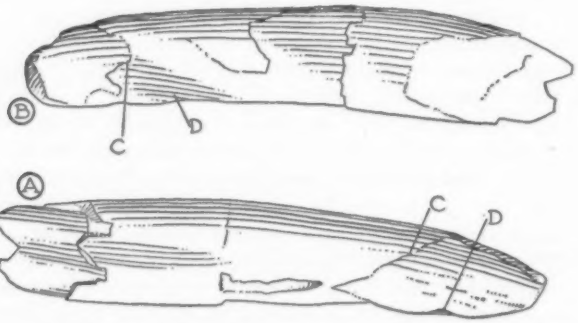

FIG. 2. Upper milk incisor, natural size. *A*, Outer side. *B*, Inner side. *C*, Base of enamel cap. *D*, Worn area. No. 3758A, Mus. Paleont., Univ. Kansas.

but the tiny Nebraskan proboscidian must have been fully developed and capable of feeding by itself.

Examples of very young individuals are probably known, but have not,

thus far, been successfully identified. H. J. Cook described and figured (1922, pp. 11, 29, fig. 213) two teeth as *incertae sedis*, but suggested that only an elephant could have such a long root on a vestigial tooth. These two teeth are incisors, and are similar in size and detail to the superior milk incisor from Nebraska. They were collected in the Beecher Island fauna (Wray beds), and, judging from Cook's figures, they do not show any traces of wear. This record is of special interest because the two faunas occur in the Ogallala formation and are of approximately equal age.

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Museum of Paleontology, University of California, Berkeley, Calif.

A NEW KANGAROO RAT FROM NORTHEASTERN CALIFORNIA

By George Willett

Recent studies of mammals from northern California reveal the existence of an undescribed kangaroo rat, which I propose to name:

Dipodomys microps aquilonius, subsp. nov.

Type.—Female adult, skin and skull; no. 3935, collection Los Angeles Museum; three miles east of Eagleville, Modoc County, California; June 4, 1934; collected, with eleven additional specimens, by G. Willett.

Measurements of type.—Total length, 272 mm.; tail vertebrae, 156; hind foot,41; length of skull, 36.1; breadth of skull, 23.9; width of maxillary arch, 3.2.

Diagnosis.—A medium sized kangaroo rat of the *Dipodomys microps* group. Coloration darker than in *Dipodomys microps microps* and *D. m. levipes*, with less extensive white ear tufts (these usually divided into two parts by a wedge of dark hairs); similar in color to *D. m. preblei*, of southeastern Oregon, but cheek pouches lined with black. In size, larger than *microps* and smaller than *levipes*; body measurements larger than in *preblei*, but skull considerably smaller in both length and breadth and, particularly, in width of maxillary arches.

Skull measurements of *D. microps*, *aquilonius*, *levipes* and *preblei* are as follows:

	Length mm.	Breadth mm.	Maxillary arch mm.
5 topotypes of *microps* average	34.6	21.8	3.3
6 topotypes of *aquilonius* "	36.4	23.2	3.3
6 topotypes of *levipes* "	38	24	3.7
6 topotypes of *preblei* "	38.1	24.4	4.3

Distribution.—So far, known only from the type locality, but its range probably extends into northwestern Nevada. A specimen from Honey Lake, Lassen County, appears to be intermediate between *aquilonius* and *levipes*.

My thanks are expressed to Dr. Joseph Grinnell and Dr. W. H. Burt for comparing the Eagleville specimens with representatives of allied races in the Museum of Vertebrate Zoology and the D. R. Dickey Collection.

Los Angeles Museum, Los Angeles, California

A FOSSIL CAMEL FROM NEVADA

By T. D. A. Cockerell

[*Plate 3*]

Some time ago Miss D. E. Welch, one of my students, brought to me a fossil camel skull collected by Mr. J. C. Rubright in Eureka County, Nevada, about twenty miles northwest of Carlin. Later, through the courtesy of Mr. J. D. Figgins of the Colorado Museum of Natural History, the specimen was thoroughly cleaned, and my colleague, Professor Hugo Rodeck, has taken the photographs herewith reproduced. The locality is in northeastern Nevada, and the age is presumed to be Upper Miocene. After careful comparison with the various published descriptions and figures, I conclude that the skull is best referred to *Procamelus robustus* Leidy, described from a lower jaw and recorded from Nebraska, Kansas, Texas, and New Mexico. The measurements do not agree in detail with Leidy's type, and while the differences may indicate a recognizable segregate, it does not seem unlikely that they fall within the limits of the species. There is a closely related genus *Protolabis*, which Hay in 1901 included in *Procamelus*, said to be distinguished by having three incisors in the upper jaw, *Procamelus* having only one. However, the premaxillae of the living Camelidae have the full number of incisor teeth in the young state, but in the adult only one tooth persists. The Nevada skull has three small incisors on each side in the premaxilla, the first 6.5 mm. from the second, the second 9 mm. from the third, and the third 14 mm. from the canine. Hence it may be a question whether to refer it to *Procamelus* or *Protolabis*, if these are really distinct genera. It also resembles *Protolabis* (and not *Miolabis*) in the concave profile of snout above, and the comparatively long and narrow molars. The end of the upper jaw was broken off. The type of *Protolabis* is from the middle Miocene, and it (*P. heterodontus* Cope, 1874) differs considerably from the Nevada skull, having the mandible more robust and the incisors larger.

The length of the Nevada skull is 365 mm.; this is considerably larger than *P. occidentalis* Leidy, but not so large as *P. elrodi* Douglass, which measures 429 mm. Other measurements, in millimeters, are: eye to end of snout,

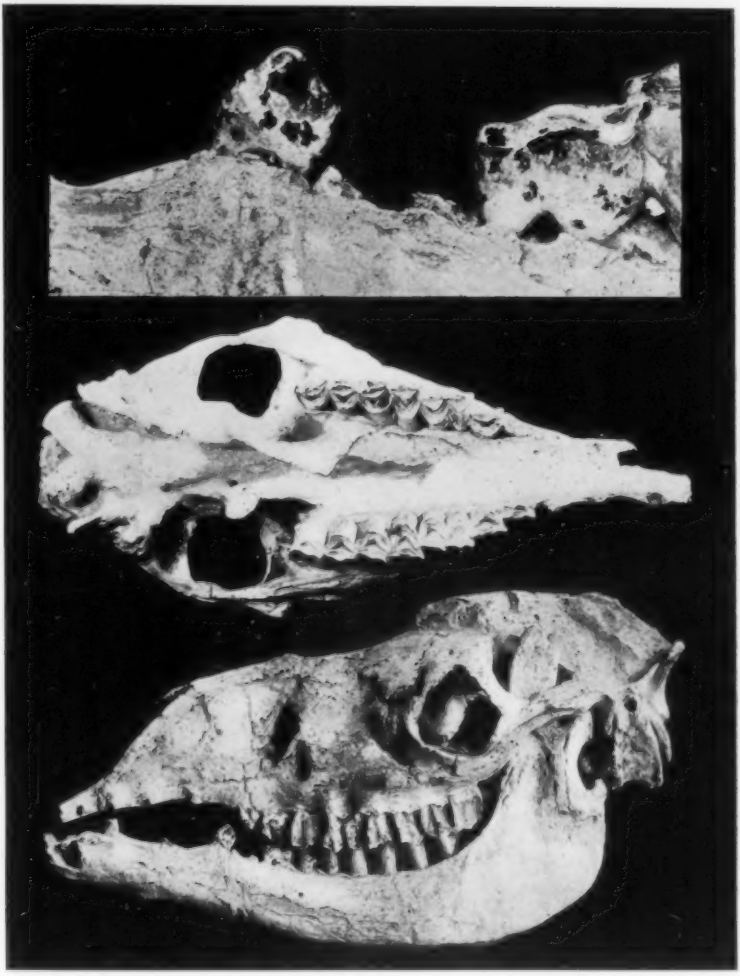


PLATE 3

SKULL OF ? PROCAMELUS ROBUSTUS LEIDY

UNIV. OF MICH.

about 195; *upper jaw*, length of molar series, m^{1-3}, 85; length of pm^{2-4}, 46.5; height of m^2 above alveolus on outer side, 17.5; distance between pm^1 and pm^2, 19; between canine and pm^1, 19; diameter of orbit, vertical 40, transverse 45; orbit to base of m^3 about 22; *lower jaw*, molar series, 88; pm_2 to pm_4 inclusive, 43; length of first molar, 26, of second, 32, of third 33 (these total 91, not 88, but there is a little overlapping); length of pm_4, 18, of pm_2, 14; height of pm_2, 11; height of m_2 above alveolus on inner side, 18.5, on outer, 16; distance between pm_1 and pm_2, 18; distance between canine and pm_1, 22; canine to presumed second incisor, 25; depth of mandible below middle of m_2, 42; below last molar, 43, on outside, 50 on inside, below pm_2, 34.5; below canine about 23; thickness of mandible below m_2, about 26.5.

Leidy's expression "hiatus back of first premolar," and in front of the same, appears to be misleading. If we read it "beyond," the measurements nearly agree with the Nevada specimen, or at any rate, are not impossibly diverse. Leidy particularly calls attention to the peculiar second lower premolar, which is triangular in outline. Our animal has the same type of tooth as Leidy's, which tends to confirm the reference to *Procamelus robustus*.

It cannot be definitely affirmed that there were not different forms (perhaps subspecies) of the *P. robustus* type on the two sides of the Rocky Mountains, or that the Nevada skull is not of a somewhat different age than Leidy's animal; but in the absence of any positive information on these points, the reference to *P. robustus* Leidy may stand. The specimen has been loaned, for an indefinite period, to the Museum of the University of Colorado.

Boulder, Colorado.

GENERAL NOTES

EARLY BREEDING OF CERTAIN CARNIVORES

All reports from field men and all young individuals of predatory species sent in to the Pennsylvania Game Commission for bounty show that weasels and gray foxes were born at least thirty days earlier this year (1934) than usual. No reason for this has appeared, especially as we had an unusually late and cold winter.—THOS. E. WINECOFF, *Board of Game Commissioners, Commonwealth of Pennsylvania, Harrisburg, Pa.*

AN ARIZONA COUGAR

During the summer of 1933 I spent five months collecting mammals in Utah and Arizona. In Arizona, I was interested not only in obtaining topotypes of the gray and fox squirrels that occur there, but also in collecting specimens of certain species not represented in the collection of the Carnegie Museum.

On September 27 I was hunting gray squirrels about a mile and a half southeast of Soldiers Camp, which is a summer resort at 7,700 feet altitude in the Santa Catalina Mountains, near Tucson, Arizona. About five o'clock in the afternoon, while stalking a squirrel that was barking some little distance ahead of me, I heard a rustle in the brush and then saw a patch of brownish-red hair flash through an opening in the trees. Because of its size, color, and movements, I was certain it was a cougar, although it was not in full view at any time. It crossed a small ravine and disappeared over the ridge to my right. As I listened to the tread of its padded feet fade away in the distance my attention was drawn to other footsteps approaching from my left. Suddenly an eight point white-tailed deer came into view. It stopped for an instant, startled at my presence, then started off along the ridge, sidling away from me at a trot. I shot it with number six shot from the choke barrel of my 16 gauge shotgun. As I carried it back to camp, there was no question in my mind but that the cougar had been lying at the crossing, waiting for the buck. If I had been a minute or two later, I might have had the unusual privilege of watching the lion make its kill.

The next morning at daylight I was again hunting squirrels along the ridge not far from where I had killed the buck. I had no expectation of seeing a cougar again, so I was more startled than before to see one dash out from the top of a fallen tree not more than a hundred feet in front of me, and take refuge in a clump of small pines on the opposite side of a clearing. This time I had an unrestricted view of it as it crossed the clearing. Since I had nothing but squirrel loads for my shotgun, I cut the paper shell of three of them so that the wads which separate the powder and shot were all that held the two parts of the cartridge together. With two of these in the gun, I cautiously approached the thicket of pines, hoping that I would see the cougar again. It came out on the upper side of the thicket, two or three hundred feet to my right, which was somewhat beyond the range of my gun. I shot at it without any apparent effect, then watched it for approximately a minute, as it ran up over the hillside through the open stand of pines, and disappeared over the ridge.—J. KENNETH DOUTT, *Carnegie Museum, Pittsburgh, Pa.*

CARNIVOROUS HABITS OF THE NORTHEASTERN CHIPMUNK (TAMIAS STRIATUS LYSTERI)

The middle of July, 1933, while I was the guest of Mr. John B. Burnham, on the shore of Lake Champlain north of Essex, New York, I learned something new to me about the habits of these attractive little animals. At one corner of a broad veranda a nesting box was attached to the upper post of a pillar supporting one corner of the roof. It was occupied by a brood of well-fledged bluebirds, the parents of which were hard at work all day supplying the insatiable demands of the young birds. One day the bluebirds

suddenly became almost hysterical in their cries of alarm, fluttering about from the nest box to other perches near by. In reply to my inquiry Mrs. Burnham said that there must be a chipmunk below the nest. Cautiously looking over the edge I soon saw him close to the porch and near the top of the shrub. He was driven away and in a very short time the birds resumed their task. On two following days two chipmunks were shot from the same shrubbery where I had seen one, both apparently intent on getting the young bluebirds while the old birds were in the same state of alarm I had seen before.

Mrs. Burnham told me that on one occasion they had caught a chipmunk killing a young robin.

On the farm of Mr. Mortimer Moss near Lewis, New York, the summer of 1932, some 15 or 20 downy chickens were killed in the coop, and the animal that did it was a mystery which was solved when a chipmunk was seen to come from neighboring cover and make straight for the coop. The destruction of this and five others doing the same at later intervals appeared to end the trouble, as no more chicks were killed. This incident was related to me by the daughter, Miss Vera Moss, who was present at the time.—Edward W. Nelson.

AN OUTSIDE NEST OF A FLYING SQUIRREL

An outside nest of a flying squirrel was noted at the Edward George Reserve of the University of Michigan, Livingston County, Michigan, on August 11, 1931. The nest was located about three-fourths of the way up a small, unthrifty white oak with a dead top. It was about fourteen feet from the ground.

From below, the nest appeared to be too small and loosely constructed to be more than a haphazard, temporary home, but a vigorous shake of the tree caused the sudden eruption of a flying squirrel, which flattened itself against the trunk about a foot above the nest and in plain view. Another vigorous shake caused it to sail to the ground and to disappear up a neighboring oak which towered high above the nest tree.

Branches close to the ground gave easy access to the nest, which was composed externally of loosely placed leafy twigs from the nest-tree. The interior of the nest was a carefully constructed ball of finely shredded bark of undetermined origin, and the entire mass was scarcely eight inches in average diameter. Inside were three or four young squirrels about the size of a small adult house mouse, still hairless and blind, but the interior and its contents were disturbed as little as possible and the exact number of young was not learned.

The next day, when Mr. Paul Hickie, Curator of the Reserve, went to corroborate the observations, a slight shaking given the tree again drove the squirrel from her home, but as she was not disturbed further, she returned immediately to the nest.

The nest was not observed again until September 8, when the family of squirrels had disappeared. The nest was collected for the Museum of Zoology at Ann Arbor.—M. F. Landwer, *Texas Technological College, Lubbock, Texas.*

A PROTECTIVE HABIT OF DIPODOMYS DESERTI

On July 22, 1931, while a guest of Mr. W. E. Ketcham at his cottage in the Mojave Desert in the vicinity of Twenty-nine Palms, San Bernardino County, California, I had the opportunity of observing that the desert kangaroo rat (*Dipodomys deserti deserti*) has the habit of kicking sand at objects that arouse its suspicions, in order to determine whether or not the suspected object is alive.

It is the custom of Mr. Ketcham to scatter food on the sand in the vicinity of his cottage in order to attract and watch the desert rodents. On the evening I was present *Dipodomys deserti* was the only rodent seen. The first kangaroo rat appeared just after sundown while it was still light. It found some small pieces of bread, went off and buried them, and returned for more, when its attention was drawn to a pile of bread

crusts lying against the back step of the cottage. The animal approached to within a foot of this pile, but was so suspicious of concealed danger that it would not go closer. It stood high up on its hind legs, sniffing and looking at the bread, whirled away in apparent fear, and returned at once, only to retreat again precipitately. It repeated this maneuver several times. Then it turned around and, with force and precision, kicked some sand on the pile with its hind feet. It whirled about immediately to watch the effect. This action was repeated half-a-dozen times. Finally, as if assured nothing dangerous was in the pile, it went up to it and began to fill its cheek pouches. Subsequent trips to the pile were made without hesitation. This skirmishing occupied about five minutes.

It was clearly evident that the kangaroo rat was attempting to find out if the bread pile concealed danger. It appeared highly probable that an animal struck by the sand would have moved enough to betray its presence to the kangaroo rat. It is likely that this habit would be of great value to the kangaroo rat when used against the sidewinder (*Crotalus cerastes*) which also lives in sandy places and is known to feed on kangaroo rats.

This observation made clear to me the reasons for finding many of my traps set off and partially buried when I was running a trap line where *Dipodomy deserti* was abundant. The amount of sand thrown by each kick, and the force with which it was thrown, was easily sufficient to spring a mouse trap or rat trap. A few subsequent kicks would be sufficient partially to bury one. I do not recall having had this experience with any kangaroo rat except *D. deserti*, and nowhere save in loose sand.—Seth B. Benson, *Museum of Vetebrate Zoology, University of California, Berkeley, California.*

YELLOW-BELLIED MARMOT OUT OF BOUNDS

May 6, 1934, my neighbor, Mr. Howard Kingen, shot a pallid yellow-bellied marmot (*Marmota flaviventris avara*) just outside the city of Bellingham, Washington, and within 50 feet of the shore of Bellingham Bay. The animal had chosen as its place of refuge a heap of discarded railroad ties on the side of a bank facing the salt water. My attention was called by Mr. Kingen to this "strange" animal which was readily recognized by me. The specimen was a male in good pelage, 22 inches in length and weighing six pounds. It is now mounted and has a place in my collection.

So far as can be ascertained this is the only recorded occurrence of this species west of the Cascade Mountains. These snow-crested ranges are an effective barrier to mammals and birds whose habitat is below the Canadian zone, except where the Columbia and Fraser River valleys cut through to afford a route for emigration. Even then the marked difference between arid and humid habitats is not conducive to such movements. The occurrence of an east-side bird species on the west side is of course not so strange as that of a mammal.—J. M. Edson, *90 Marine Drive, Bellingham, Wash.*

PINE MOUSE IN ESSEX COUNTY, MASSACHUSETTS

In May, 1933, a small colony of pine mice—*Pitymys pinetorum scalopsoides* (Audubon and Bachman)—was found in Saugus, Essex County, Massachusetts, about nine miles north of Boston. The pine mice were on the summit of a wooded knoll, mixed pine and hardwood, east of Lily Pond. *Peromyscus* were common on the sides of this knoll, and in other woods in the vicinity, but the pine mice were restricted to an area of a few hundred square yards around the summit of the knoll.

This singularly restricted colony represents a noteworthy extension of the recorded range of this species, and is apparently the first record for eastern Massachusetts. Crane (1931, this journal), recorded a specimen from Northampton and cited Allen's 1869 record of two specimens near Springfield—all from the Connecticut River valley in western Massachusetts. Several of my Saugus specimens of pine mice are preserved in the Museum of Comparative Zoölogy, Harvard University. Dr. Glover M. Allen, Curator of Mammals of the Museum, tells me he knows of no previous record of pine

mice in eastern Massachusetts. One can only speculate as to when and how and from where the ancestors of this colony reached this knoll in Saugus. It seems likely that this extension of range was made possible by a series of mild winters. The winter of 1933–34 was an unusually severe one in New England. In the spring of 1934 trapping in the same habitat revealed no evidence of pine mice.

One of the pine mice, trapped alive and uninjured in May, 1933, was placed in a wide-mouthed gallon glass jar, and kept for observation. "Pitymys," as he was called, became an interesting and popular family pet. He was taken to Maine when the family went there for the summer, and was undoubtedly the only mouse of his kind in the state.

For building material, Pitymys was supplied with two or three handfuls of dead pine-needles, thrown loosely into the jar. He would spend several hours of hard work arranging this material to form a series of sub-surface tunnels, leading to a concealed nest—which he lined with absorbent cotton or soft cloth when such materials were made available. For several hours after the construction work was completed, Pitymys would stay in retirement, resting. Food (cornflakes or other cereal) and water were supplied in two small glasses. The openings of the tunnel system were beside the food and water dishes. Carrots or potatoes placed in the jar were buried by undermining. Clover leaves were another favorite food; when offered they were dragged into the tunnels, and eaten in seclusion. Pitymys spent most of his time "underground," but made several appearances at the surface each day. His activity was not limited to any special time of day or night, and therefore he made a more interesting pet than *Peromyscus*, which is strictly nocturnal. He never made any attempt to jump or climb out of the jar.

As the glass jar habitat provided no drainage, the jar had to be cleaned and the needles renewed once a week or oftener. Pitymys was placed in a small transfer bottle while the jar was being cleaned. He showed no alarm, and when replaced in the jar with a fresh supply of needles he proceeded vigorously to bring order out of chaos, not resting until a new nest and tunnel system had been arranged.—MAYNARD S. JOHNSON, *Zoological Laboratory, Harvard University, Cambridge, Mass.*

DIURNAL MATING ACTIVITY OF THE COTTONTAIL

On the afternoon of May 13, 1934, while crossing a clover field near Union Springs, N. Y., a small group of students, including the writer, noticed three cottontail rabbits (*Sylvilagus floridanus mearnsi* Allen) moving about in the open, perhaps one hundred yards away. One animal was being followed by the other two at intervals of a few feet, and it was soon evident that courtship was in progress. The trio zigzagged back and forth but moved constantly down the gentle slope of the field toward the group of watchers. At intervals the first rabbit, presumably a female, would pause for a few moments. The nearest male would then overtake her and, with ears laid back, attempt to mount her. Almost at once she would hop along again and the pursuit would continue. This was repeated three or four times before the animals had reached a distance of about fifty feet from the observers. At this point the female and nearest male were obscured from view by an outcropping of bushes. The second male had become either alarmed or discouraged and moved back up the slope toward the wider part of the field. Throughout the performance, headlong haste was exhibited by neither female nor males—the three hopping along in a rather leisurely fashion. At no time was there evidence of violence on the part of either sex.

The time of the observation was 4:30 P.M.; the weather partly cloudy; the temperature slightly above 70°F.—E. E. BROWN, *Cornell University, Ithaca, N. Y.*

ABNORMAL MANDIBLE IN WHITE-TAILED DEER

An abnormality that, so far as I am aware, is of rare occurrence, was found in white-tailed deer shot in the Adirondacks of New York in the fall of 1933. In this specimen the lower jaw was so short that the incisor teeth met the upper jaw nearly

an inch behind their normal point of contact. The head of this deer was received for mounting by George E. Wilcox, of Borodino, New York, to whom I am indebted for a chance to examine the specimen. I first saw it after the skin had been removed, but the opportunity for more detailed examination did not come until some weeks later, when the cleaned skull was at my disposal.

This deer was a "spike-horn," that is, approximately eighteen months old. According to Mr. Wilcox, it seemed to have been in average condition of flesh, so that the shortened jaw apparently had not affected its feeding ability to any noticeable extent.

It is evident at a glance that the shortness of the mandible is due, not to general underdevelopment or stunting of the structure as a whole, but only of that part of each mandibular body which lies between the first premolar and the mental foramen. The cheek teeth occupy normal relations with the teeth of the upper jaw, and the section of the mandible from the mental foramen to its tip at the symphysis is likewise evidently normal for an individual of the age and size of the specimen in question. But the portion of the mandibular body between the first premolar and the mental foramen is proportionately much shorter than in the normal condition.

To make this clear and to show the degree of abbreviation in the affected part of the mandible, a few measurements of the abnormal specimen and of two available normal mandibles of male white-tails are presented below. One of the normal specimens represents an individual about two and a half years old, the other, one of about three and a half years, as judged by the antlers and the condition of the teeth.

Measurements.—Distance from anterior margin of first premolar to posterior margin of mental foramen, abnormal specimen, 25 mm. (normal specimens: 42 mm.; 43 mm.); distance from posterior margin of mental foramen to tip of mandibular bone at symphysis, abnormal specimen, 31 mm. (normal specimens: 34 mm.; 34 mm.).

It is thus seen that, whereas in the normal mandible the distance from the first premolar to the mental foramen is much greater than the distance from the foramen to the tip of the mandible, in the abnormal specimen this distance is considerably less than the other. And the biting edge of the incisors, when the jaws are closed, falls 20 mm. behind the front edge of the premaxillaries.—CHARLES E. JOHNSON, *Roosevelt Wild Life Station, N. Y. State College of Forestry, Syracuse, N. Y.*

ONCHOCERCIASIS, A NEW DISEASE IN THE WHITE-TAILED DEER OF MONTANA

Sporadic reports have been made by hunters and local residents in Montana for several years regarding deer with foot disease, and in nearly every case the cause has been attributed to the foot-rot disease common to domestic sheep.

In November, 1933, the writer examined the feet from a white-tailed deer killed by a hunter in the Thompson River country of western Montana. The claws of the second and fifth digits were loosened or missing from all four feet, and the claw on one of the main toes was also loosened. The region above the toes was badly swollen and numerous ulcers, particularly on the fore part of the foot, were evident. Some of these had attained a size of about an inch in length (figs. 1 and 2).

Upon dissection, each foot yielded 20 to 30 long, white, very tough nematodes which have been identified by E. W. Price of the U. S. Bureau of Animal Industry as *Onchocerca flexuosa*. The greater number of these parasites were extended in the subcutaneous tissues, but some were coiled in a cyst and these had created, or were in the process of creating, an open lesion through the skin. One large lesion (fig. 2) was probably caused in part by mechanical means in an effort by the deer to alleviate the irritation by striking its foot amongst brush stubble.

There was no evidence of infection by *Actinomyces necrophorus*, the causative organism of foot-rot disease in domestic sheep.

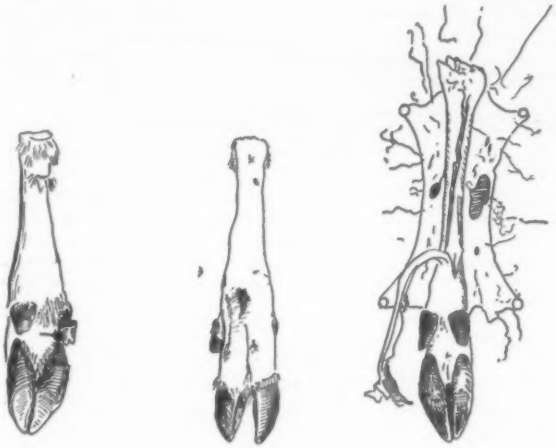
On February 13, 1934, another specimen of infected deer was secured from Thompson

River. All four feet were heavily infected with *Onchocerca flexuosa*, but the open lesions in the skin were absent and the swelling not so great as in the former specimen. The parasites were found extended in the subcutaneous tissues and the connective tissues of the flexor tendons, some of them being about ten inches long. None were in the cystic form, as found in the first specimen (fig. 3).

The life history of *O. flexuosa* is not known, but in common with other genera of the family *Filariidae*, the larvae are probably transmitted by flies or mosquitoes, whose larval development is in the water.

It is planned to determine the incidence of the disease next hunting season, October 15 to November 15, by having the hunters send in for examination the feet of the deer they kill. Field observations will also be carried on to determine the effect of the disease on the deer of this region.

The accompanying drawings are by O. J. Murie.—W. M. Rush, *U. S. Forest Service, Missoula, Mont.*



A CORRECTION

In a small paper describing a new species of dolphin, *Prodelphinus graffmani*, from the Pacific coast of Mexico (Arkiv för Zoologi, vol. 26, no. 19, Stockholm, 1934) the undersigned author, through a deplorable slip of the pen, on page 6 unconsciously has written "J. A. ALLEN" instead of GLOVER M. ALLEN, although he very well knew that the latter was the author whom he intended to quote. This fault, due to an accidental distraction, he now wishes to correct.—Einar Lönnberg, *Stockholm, Sweden.*

NEW DEVELOPMENTS IN A SMALL MAMMAL TRAP

While live-trapping, marking, and releasing small mammals in the fall of 1931, I found that the animals died of cold in the traps, despite all the precautions that could be taken, such as covering the trap with insulating material, placing cotton in the trap, etc. It was apparent that a larger nest box and more nest material were necessary. To have a nest box of sufficient size to prevent the animals from freezing, attached to

the trap itself, would make the whole unnecessarily cumbersome, hence an attempt was made to develop a trap-unit that would be separate from the nest box.

The trap, as constructed, is a modification of the "Delusion" or "Catchemalive" mouse trap. Fig. 1 is a side view of the trap-unit. Fig. 2 is a combined cut-out perspective view showing the trap as it is when set. For carrying, the trap-unit (A) slides into the box (B), and a door fits into the vertical slots in the front of the box the same as at the rear.

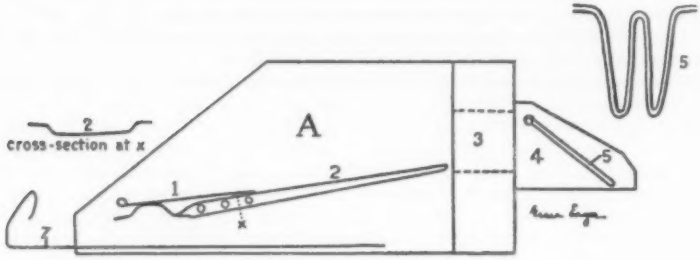


Fig. I

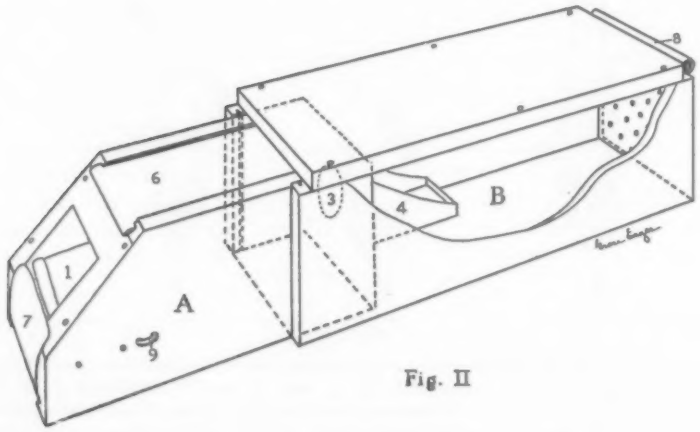


Fig. II

In entering the trap, the animal walks over the front door (1) to the back of the pan (2) where his weight depresses the pan. This closes the front door, leaving only the exit (3) (one inch diameter) to the rear. The animal next goes through the trough (4), at the same time raising the wire door (5) which drops back into position as soon as released. As soon as the pan is freed of weight, it moves upward to its original position, allowing the front door to reopen, and thus the trap is reset. The top (6) and the bottom (7) of the trap-unit are pieces of tin fitted into slots and are removable, allowing easy access to the moving mechanisms of the trap. The bottom, while not absolutely

necessary, serves both to protect the pan from outside interference, and to insure a tighter trap suitable for such things as small shrews. (Shown partly removed in fig. 1.) The box (B) has tin doors (8) in front and back that fit into vertical slots and are removable. These are perforated with eighth-inch holes at intervals of half an inch, a size suitable to obviate scraping the nose of the occupant. The pan is pivoted on a wire (9) which may pass through any one of three holes in the sides of the trap, and through any one of three holes in the pan (see fig. 1), thus giving a fairly wide range to the weight necessary to work the trap. The rear of the trap-unit is made of one-half inch material, the sides of the trap-unit and the box of ¾-inch material. The trap figured is designed for field- and woods-mice, etc., but it could be made in other sizes suitable for larger mammals. The figures are drawn to scale.

For cold weather trapping a large nest box is used. This allows space for a quantity of nest material and likewise gives the animals enough room to move about so they do not become cramped and freeze to death. The dimensions of this box are six inches high by one foot square. A hole the size of the trap-unit is cut in each of the four sides of the nest box and the trap-units inserted in these. However, any size of box may be used and more or fewer holes cut in it for the insertion of the trap-units.

It was apparent that a large nest box would be unnecessary for summer trapping. In the interest of compactness, the nest box is just large enough to allow the trap-unit to telescope into it, thus making the complete trap but little larger than the trap-unit. Since the two parts are separable, the nest box may be used as a carrying case, while another nest box is slipped onto the trap unit, and the trap reset.

Following up the telescopic idea, as many nest boxes as desired may be added, each one only increasing the size of the trap by the thickness of the material used in making the nest box, but greatly increasing the holding capacity of the trap.

To summarize, this trap seems to combine the following advantages: first, it is a multiple-catch trap; second, it can be used in both winter and summer; and third, it can be made to combine compactness with large holding capacity.—Paul Hickie, *Department of Conservation, Lansing, Michigan.*

RECENT LITERATURE

Simpson, George Gaylord. ATTENDING MARVELS. A PATAGONIAN JOURNAL. 295 pp., 16 illustrations. The Macmillan Co., May, 1934.

Under this somewhat ambiguous title Doctor Simpson presents the story of his experiences while engaged in hunting fossils with the Scarritt Patagonian Expedition of the American Museum of Natural History, 1930–31. In the foreword he says: "This is an account of a scientific expedition, but it is more concerned with people and events and places than with science." In spite of this disclaimer, science is by no means neglected and we find here a graphic picture of the topography and geology of Patagonia, with vivid descriptions of the more prominent animal life.

The chapter on "Ancient Beasts" gives in very readable style a brief history of paleontological explorations in Patagonia from the time of Darwin's visit in 1833 to the present; explains the importance of the very ancient mammalian fossils found in South America to an understanding of the evolutionary history of that continent; and describes the methods employed in hunting for fossils and extracting them from the rocks in which they are embedded.

A chapter entitled "Children of Patagonia" is devoted to an account of the few common and noticeable species of living animals. Of these, the guanaco and the South American "ostrich" (*Rhea darwini*) proved to be almost constant companions, and many interesting details of their habits are recorded, both in this chapter and at other points in the story. To quote a few paragraphs about these two:

"Patagonia is the guanaco's country. He is better adapted to it than we are and he belongs there. The country and its most typical animals belong together. A Patagonia without its guanacos would be dismal indeed, unthinkable. Ungainly, ugly, and irrational as he is, the guanaco lends to the region much of its life and interest. Long may he survive, sentinel of his native pampas!"

"He and the ostrich. Unlike as they are, these two seem to go together. Both are ridiculous, unbeautiful, and stupid; both are at home in Patagonia; but there the resemblance ends. Yet to think of one is to think of the other, and any mental image of the high pampas will have both in it."

Of the smaller beasts encountered, the most prominent appears to be the armadillo, *Zaëdyus pichiy*, one of which was kept as a camp pet and many others served in the camp fare. The so-called "Patagonian hare" [*Dolichotis magellanica*] is said to be rare, doubtless as a result of the introduction of European hares a few years ago. Two kinds of "foxes," two of wildcats, skunks, weasels, and pumas are mentioned. Zoologists would have been better pleased if these animals had been specifically identified, but doubtless this will be done in the scientific reports of the expedition, which are appearing elsewhere.—ARTHUR H. HOWELL.

Dixon, Joseph S. A STUDY OF THE LIFE HISTORY AND FOOD HABITS OF MULE DEER IN CALIFORNIA. California Fish and Game, vol. 20, no. 3, July, 1934, pp. 181–182, and No. 4, October, 1934, pp. 315–354. (Contribution from Wild Life Division, U. S. National Park Service.)

From the viewpoint of either the game manager or the ecologist, this is the most important paper so far published on any species of American deer. It represents several decades of field study by a biologist who is also an expert woodsman. The author, I infer, has accomplished the transition from the ideology of the old-time field naturalist to that of the modern ecologist without losing the good points of the one or adopting the fussy trappings which sometimes go with the other.

The title of Dixon's paper accurately describes its scope. Part I treats of taxonomy, characters, habits, breeding, enemies, and diseases, with an average penetration far above the usual. Each page exhibits a wealth of field observations, boiled down,

pertinent, and arrayed in support or contravention of moot questions with both discrimination and justice. I can offer only one criticism. The author does not conceive of population as an entity with characteristics of its own. He does not habitually attempt to translate the observed character of the individual animal into its more elusive population characters. For example: Within what characters of the individual are we to seek the explanation of such population behavior as the irruption on the Kaibab? Despite the excellence of Dixon's data on the individual deer, there is a significant scarcity of speculation on characteristics of deer herds. The sketchy treatment of sex and age composition of populations corroborates the conclusion that in this respect Part I falls somewhat short of the "ecological viewpoint."

No such criticism can be made of Part II on food habits. Nearly every page elicits (from me) ejaculations of pleasure on how far the author has gone above and beyond the old-fashioned concept of cross-sectioning a species and then announcing "here is a list of its foods." Only Stoddard, McAtee, and Errington have gone as far as Dixon in exposing that intricate network of forces through which time and circumstance influence diet. For each of dozens of food items Dixon has dug out the "ifs and ands" which determine consumption, and in not a few instances he speculates briefly and keenly on the effects in terms of population. For example: Weaning requires green grass in September. If there be none, weaning is not accomplished. Both doe and fawn enter the critical winter season in subnormal condition. Here the reader is led up to the very brink of the canyon of the unknown and given a real glimpse of one of the many forces which determine "the presence or absence of animals." Here is dynamic ecology.

Again, does are observed to stuff themselves on willow leaves just before fawning, but not earlier nor later. This is at least a hint that willow leaves have some definite physiological function. Immediately the reader can visualize the millions of acres of mule deer range from which cattle have eliminated willows, but to which willows could be restored by grazing-control or fencing. However speculative now, this is the stuff that game management will ultimately be made of.

The short section on management policies is disappointing. One may, in fact, feel actually skeptical about such assertions as: "I feel that the control of hunting is fairly well provided for under existing California game laws." Actually, this is outside the scope of the work and had as well been omitted.

Dixon's work on deer so far includes no controlled experimentation, no banding studies. In this respect it falls short of the standard set by Stoddard in his quail studies. Many of his observational deductions, however, could be experimentally verified. If thus rounded out, the present paper could become the foundation of a species monograph comparable in character to Stoddard's "Bobwhite."

Dixon's photographs are, as always, superb in quality and always to the point.

The California Commission is to be congratulated, first on their discrimination in making room for this admirable paper in their sportsman's periodical, and second, for their foresight in reprinting the two parts in a single cover, with index, and making the volume available at a nominal cost.

The Park Service also merits commendation for the now obvious quality of its research output. Following close on the heels of its "Fauna of the National Parks," this paper definitely establishes the Park Service as one of the groups which are building American game management.—ALDO LEOPOLD.

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Anyone interested in any phase of mammalogy is eligible for membership in the American Society of Mammalogists, and if elected will receive the Society's official publication, the Journal of Mammalogy, quarterly. Name and address, with remittance of $3.00 for annual dues, may be sent to the Corresponding Secretary, or to any officer of the Society. Membership is dated from the nearest January, although formal election will not take place until the annual meeting of the Society following the receipt of application.

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Examples:

CHAWORTH-MUSTERS, J. L. 1933. On the type-locality and synonymy of *Ochotona pusilla* (Pallas). Ann. and Mag. Nat. Hist., London, ser. 10, vol. 12, no. 67, p. 137. July, 1933.

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The seventeenth annual meeting of the American Society of Mammalogists will be held at the Carnegie Museum, 4400 Forbes St., Pittsburgh, Pa., from Tuesday, April 30, to Saturday, May 4, 1935. Headquarters: Hotel Schenley.

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